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ABSTRACT

This curriculum guide for alternative energy courses is part of a series of curriculum guides for use in the industrial arts curriculum in Connecticut. The guide contains two parts. Part 1 provides the following overview: (1) objectives of alternative energy education, including suggestions for course levels, class sizes, teaching methods, and student organizations; (2) references; (3) a bibliography of solar teaching aids; (4) tools and equipment needed; (5) a glossary; (6) multi-media materials; (7) resource organizations and agencies; (8) solar suppliers; and (9) metric conversions. In the second part, seven units for teaching alternative energy concepts are provided. These units are independent entities and cover the following topics: conservation, insulation, thermal storage systems, climate control systems, greenhouses and atriums, solar domestic hot water systems, and envelope and hybrid climate control systems. Each unit contains an introduction, information sheets for implementing the course, and behavioral objectives. Material is illustrated with line drawings and photographs. (This curriculum guide has material for both secondary and adult vocational education courses on alternative energy.) (KC)

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INDUSTRIAL ARTS CURRICULUM GUIDE
FOR
ALTERNATIVE ENERGY

Connecticut State Department of Education

Division of Vocational and Adult Education

May, 1982

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PART II IMPLEMENTATION

NOTE: This unit has its own table of contents to facilitate its use.

PART I

OVERVIEW

I. ALTERNATIVE ENERGY

CURRICULUM COMMITTEE

Stuart F. Bevis
Portland Jr. High School
Portland, CT

Werner R. Friess, Chairman
Staples High School
Westport, CT

Jim W. Hodrinsky
Enrico Fermi High School
Enfield, CT

Frank C. Katona
Whittier School
Bridgeport, CT

Robert Kenney
Johathan Law School
Milford, CT

Edward Makuck, Secretary
Carrigan Middle School
West Haven, CT

Thomas Penna
Hamden High School
Hamden, CT

Norman P. Twtchell
E.C. Goodwin Technical R.V.T.S
New Britain, CT

Mitchell J. White
Torrington High School
Torrington, CT

II. ACKNOWLEDGEMENTS

CIAA Professional Improvement Activities

Connecticut Industrial Arts Association

Connecticut State Leadership Council

Energy Outreach
Connecticut State Energy Division
Alice E. Holmes

Porter and Chester Institute for Technical Education
W. L. Brown, Director

Connecticut State Department of Education
David M. Mordavsky
Consultant for Industrial Arts
Bureau of Vocational Services

U.Maine, U.Conn, and C.C.S.C. Summer Sessions

Dr. John W. Bartok, Jr.
Extension Agricultural Engineer
UCONN

Jeffrey Carusone
Student
Staples High School

III. FOREWORD

This curriculum is the crystallization of several years of frustration with the prevailing energy source, petroleum. Since the early 70's, we have been puppets alternately manipulated by oil producers, industrial requirements, political inter–play, and consumer needs.

This nation almost went solar in the early forties. In fact the history of "modern" solar housing began at the turn of the century. Within the first half of this century the modern American solar home was developed.[1] Then, however, the glut of oil production, a product of W.W.II, created cheap energy in America and deterred solar induced Alternative Energy for some thirty years.

The euphoria is gone. Reality is here, and so let us not again be mislead by misinformation, quick profits, and the easy way out. The future is a reaffirmation of man's early history and subsequent development where alternative energies abounded. Let's squarely face our current and future dilemma - a replacement for expensive and scarcening petroleum as well as dangerous nuclear energy. Within our educational system we must train-up our young to think solar-alternative energy, i.e., alternative energy in the larger sense.

---

[1] New Shelter - Rodale Press, "America Almost Went Solar", March, 1980, p. 94.

The need is one of guidance and direction, of established minimals and suggested maxima, of width and breadth, of perceptive identification and clarification to and for the total field of A.E. as it exists currently, whether it be in the activity of "living, work, or play", and to this must be added the plethora of ramifications which are on the horizon of tomorrow.

To this end, this effort has been developed cooperatively by the teachers and administrators in the Industrial Arts area and its state affiliation, the Connecticut Industrial Arts Leadership Council.

Alternative Energy
Curriculum Committee

IV. PREFACE

The information presented in this overview should be considered as a set of goals[1] rather than as a set of objectives. It is not the intent of this overview to spell out course specifics to the intended users when they should be developing their own specifics relative to local needs and requirements with regard to the student, the community, and the teacher. Therefore, be it noted that you, the instructor, must be specific in constructing your objectives with or without behavioral[2] inflections.

---

[1] A goal is a general statement while an objective clearly specifies what the pupil will do and how it will be measured.*

[2] (1) Behavior involving manual, motor, neuromuscular of physical skills are called psychomotor behaviors.
(2) Behavior dealing with feelings, emotions, attitudes, values, interests, and appreciations is called affective behavior.
(3) Behavior dealing primarily with mental or intellectual processes is called cognitive behavior.
(4) Overt and covert behaviors can be classified in three domains: the cognitive, the affective, and the psychomotor. The utilization of domains serves to simplify the process of specifying objectives. However, few objectives (behaviors) are purely cognitive, affective, psychomotor. We are accurate when we speak of highly cognitive, or highly affective, or highly psychomotor.

* Robert Hale, Director Instructional Materials, Branford School System, Branford, Conn., Nov. 1975

V. PREFACING OBJECTIVES

I. Goals of Contemporary Industrial Arts A.E. Education

The reality of petroleum induced cheap energy definitely appears to be a thing of the past. Thus, we in industrial arts must be in the forefront of the battle to insure survival in all those areas of public need which even now seem reluctant to sever the knot of petroleum servitude to "ease of use" and "Don't rock the boat" kind of strategy. This, in spite of all the economic ramifications of controlled scarcity, high prices, lagging economy, inflation, etc. Industry is reluctant to change from petroleum energy because it is accessible at a price for yet a limited time - all, for the sake of profit only. The average consumer is aware of impending changes in the energy picture and becomes increasingly concerned. Yet the government currently in 1982 is doing little to change to alternative energy sources. Truly, the most imposing goal of all is to convince this nation that we must begin the task of all-out research, development, production, and utilization activities that will enhance all existing solar induced alternative energy methods and devices, as well as to create new ones. Nuclear is not viable at this point due to its continued polluted waste by-products and the ever constant danger of greatly increased radiation poisoning of ourselves and the landscape we inhabit. This new energy goal requires: 1) Realization, 2) Acceptance, and 3) Implementation. Let us, in Industrial Arts, whole-heartedly become involved in the total process. Education has always shown the way. Now let this education and the resultant concentrated learning be the impetus that will lead to a better energy tomorrow.

Industrial Arts can supply very clear realistic goals to achieve alternative energy independence. The following five are being advocated and are believed to be unique to the Industrial Arts area.

A. Develop an Insight and Understanding of the A.E. Domain and its place in our Culture.

B. Discover and Develop Talent, Aptitudes, Interests and Potentialities of Individuals for the Technical and Applied Science Pursuits in the vast emerging many faceted ramifications of the solar induced Alternative Energy domain.

C. Develop an Understnading of Alternative Energy processes and their relationships with Practical Application of Scientific Principles.

D. Develop Basic Skills in the Proper Use of Common Industrial Tools, Machines, and Processes as they apply to A.E..

E. Develop Problem-Solving skills and Creative Abilities Involving the Materials, Processes and Products of Alternative Energy.

II. The Grade Level Breakdown of Industrial Arts Alternative Energy Goals As Related to the Worlds of Work, Recreation and Living.

A. K-5 or K-6 = Primary

1. Specific Objectives of the Area - Primary (Level One)

a. Grades K-5 or K-6, first informal introduction to the Alternative Energy area.

b. Alternative Energy in the simplest form, that of local residential home usage, ought to be integrated and be an experiential part of all the learning areas commensurate with grades K-5 or K-6. Specifically, K-6 would utilize the following applied objectives primarily as a means of thinking through, and by their use, chart directions of construction and understanding, and use these to enhance, i.e., to make richer and more meaningful, any and all areas of said elementary learning, including those career aspects of Alternative Energy that are found in the geographic neighborhood.

2. Applied Goals Breakdown
   a. How to follow directions
   b. Development of neatness
   c. Disciplined reasoning and organization
   d. Development Awareness of visualizing end results for given actions
   e. Developing use of pictorial directions for Alternative Energy project solutions
   f. Ability to analyze utility and effectiveness of applied situations

g. How to design simple Alternative Energy creators

h. How to read solar, thermal, weather, and other related graphs

i. How to read maps related to ecology, contour, forest, mine, etc.

j. Development of vocabulary with regard to above

B. Grades 5-8, 6-9 or 7-9 = Intermediate (Level Two)

1. Specific Objectives of the Area - Intermediate (Level Two)

Grades 5-8, 6-8, 6-9 or 7-9, Exploratory Phase One

A.E.[1] at this stage, applied to the middle and/or junior high school level, ought to lend itself to a functional dealing with problems of everyday concern at the interest levels of the groups to be served. Activities ought to manifest the importance of reading A.E. prints, planning. Simple A.E. systems and constructing them for observation and designing achievement data. In short, to become realistically aware of current A.E. forms, their enhancement for man, and the ecologies health and preservation. Specifically then, the emphasis ought to be on exploration rather than specialization with the technique of problem solving utilized heavily as a group or individual activity level in the meaningful solution of relevant problems . . . for all students, both boys and girls. In addition, the second phase of career education - orientation - should crystallize at this, the second level.

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[1] A.E. - Hereafter this abbreviation shall be used in place of Alternative Energy.

2. Applied Goals Breakdown
   - a. Cleanliness, neatness and orderliness
   - b. Critical thinking
   - c. Resourcefulness
   - d. The ability to follow directions
   - e. The ability to pictorialize A.E. applied solutions

f. The ability to read A.E. and related systems drawings

g. The ability to creatively visualize A.E. systems, applications, and end results

h. Perseverence

i. Honesty

j. Time consciousness

k. Accuracy

l. Open mindedness

m. Self-dependence

n. Self-discipline

o. The ability to develop academic skills in relation to A.E. and its domain

p. Responsibility

q. Knowledge and skills in the use of materials, tools, and equipment on the first formal step of A.E. realization

C. Grades 9-12 or 10-12 = Secondary (Level Three)

1. Specific Goals of the Area - Secondary (Level Three)

Grades 9-12 or 10-12, Exploratory, Phase Two;

Specialization, Phase One

The A.E. domain, as applied to the high school grades 9 or 10 to 12, ought to initially evolve from exploratory orientation to one of concentration with the world of the consumer, then that of the world of work or career orientation. Experiences with tools, processes, and materials in the applied solutions of problems of concern - group and individual - ought to point toward functional consumer adaptation, to college or institute, and to vocational skill requirements at the highest level of specialization.[1] Specifically, the goal ought to be one of developing in each student a degree of skill in the utilization of A.E. techniques, systems, adaptations, practices, evaluation, improvement and materials, tools, and equipment which will enable him/her to express ideas pictorially and to solve everyday problems according to accepted A.E. systems standards. Yet, sight should not be lost of interdisciplinary application of as many A.E. domain elements as are feasible. Functional correlation with the balance of the high school curriculum ought to be pursued for a meaningful total experience.

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[1] C.I.A.A., C.I.A.L.C., July 1971 Consensus Outcome.

2. Applied Goals Breakdown

    a. Accuracy/Precision
    b. Speed/Time consciousness
    c. Legibility and neatness of pictorials, B.M., and specifics
    d. Critical Thinking, Problem Solving, Research and Development
    e. Development of orderly, systematic sequence of operations
    f. Consumer Awareness
    g. Sense of Responsibility
    h. Principles of Standardization
    i. Leisure Time Utilization
    j. Occupational Orientation

k. Personal Traits (Habits and Attitudes)[1]

1. Cooperation
2. Leadership and fellowship
3. Understanding
4. Appreciation of achievement
5. Honesty
6. Perseverance
7. Cleanliness/personal

D. Grade 9 Clarification

It should be noted that the 9th grader is normally in the throes of evolving adolescence. The student is neither a child nor a true adolescent and, therefore, should have tailored for him an experiential area within the A.E. domain.

Although career oriented, it nevertheless ought to be involved with both exposure and some skill learning depending on the student's needs and desires, in that order. This will insure the desired broad base where both abstract and relevant problem solving occur. To re-emphasize, the accent here is on fundamentals through applied exploration rather than on specifics, as opposed to the vocational approach.

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[1] Estabrooke & Karch, 250 Teaching Techniques, 1947, p. 104

E. Grade 10 Clarification

This area ought to be the first step of the sequence of functional A.E. experiences. These are experiences which not only provide additional career orientation, but very basic and fundamental learning. They should embody all of the Passive Area fundamentals and implementation, plus essential enrichment relative to student needs and industrial practice. Add to this: increasing college and technological demands.

F. Grade 11 Clarification

This area ought to be the second step of the formal A.E. sequence. In fact, it ought to be the first real stage of specialization in career orientation of the active A.E. area. This category is based on interest and ability, the second step beyond the basic A.E. domain as offered at the 9th grade level.

G. Grade 12 Clarification

This area, the third step of the formal A.E. domain sequence, is based largely on the hybrid area of the A.E. domain and the interests and abilities demonstrated by students. During this period of intensive specialization, greater time allotments should be considered. In-depth refinement of attitudes and skills related to the area of specialization will result in the decided enhancement of marketable skill(s). Specialization in varying aspects of the advanced A.E. offerings should lead to functional articulation with the college and technological demands, to the development of job entry skills as applied to the world of work, and to functional application and maintenance of consumer systems.

III. Time Involved (Overall length of program(s))

The time span for a program is governed by many factors within any school system. The time involved for any program could be composed of the following time blocks:

A. Yearly

B. Semestral

C. Quarterly

D. Weekly

E. Daily

F. Any other

IV. Course Level

It should be noted that no curriculum guide ought to be used in grades K through 5 or 6 where Industrial Arts in general serves to enhance the existing program only. (No breakdown follows here.)

In the Middle school, 5-8, or Junior High, 7-9, the course level of the A.E. domain should point towards orientation into the broad areas of A.E. - use as applied to the worlds of work, of living, and of leisure time. It must be noted again, that this course level should be Industrial Arts, not vocationally oriented. It should be correlated with the existing programs wherever and whenever possible.[A]

[A] This would be interdisciplinary education in the finest, most functional form. - The editors.

Greater emphasis can be placed on career orientation, the world of work, only as the 9th grade level is reached. At this time, the A.E. domain offering might well be the first formal A.E. course experienced by those students who indicate an aptitude for college and technical or scientific education.

A. Grades 6-7-8

1. Exploratory in nature
2. Open to all
3. Emphasis on everyday problem-solving relative to school/home/community
4. Activities should encompass all three centers of concern:
    a. World of living
    b. World of leisure
    c. World of work (in individual and group activities)

B. Grades 9 or 10-12

1. Exposure relative to enrichment for other disciplines, i.e., Sciences, Mathematics, Fine Arts, Consumer Core, Business Education, Home

Economics, etc.

  a. Fundamental use of tools as per General Shop application.

  b. New processes and tool skills to be learned only when demand requires it.

2. Career Orientation

  a. College preparation - engineering institutes

  b. Vocational/technical - industrial

  c. Terminal and/or work experience - industrially oriented - in conjunction with bona-fide industrial application - outside of school

3. Leisure time/Consumer competence

This area should be open to anyone with or without prior A.E. experience. It is strictly needs-centered relating to the worlds of living and play. As such, it would provide overview and exposure only, with no attempt at skills or industrial techniques. It should provide an insight into the nature of the A.E. domain, positive and negative, so as to better be able to cope with it in its many ramifications for better consumer living, as well as more enjoyable leisure time participation. To insure this aspect, it ought to be provided on a ¼, a ½, or 1 semester approach, or any combination thereof to insure the involvement of as many students as possible.

4. Student Course Level

Refer to individual courses, i.e., students explore in greater depth a wider variety of areas, evaluate their performance, aptitudes and interests, formulate career plans and begin preparing to maximize their career options.

V. Size of Class

Industrial Arts, as a discipline, ought to have no bearing on the class size of grades 4, 5, or 6. More demanding criteria, other than Industrial Arts centered activities, govern this.[1]

Increasingly, however, from 5, 6, or 7 on through grade

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[1] Bureau of School Buildings, Hartford, "Table of Recommended and Minimum Areas For Educational Facilities", Connecticut State Department of Education, re: class size, physical facilities, and pupil state aid, p. 1

12, class size does become a factor. For, since individualization and specialization are ultimately desirable for the fullest realization of individual potentials, classes should not be overloaded, at this latter stage.

Therefore, factors of concern are actual space commitment, pupil demand, administrative policy governing class size, and state recommendations for minimal plant size re: pupil assignment. Realistically, a new educational situation, plant offering, and desire for state aid, must meet the basic minimals of 120 square feet per pupil for A.E. as a doing shop to qualify. In addition, the state-suggested maximum number of pupils for this type of activity class is sixteen for one teacher. Thus, any local administration may act accordingly, since local control is basic. It may accept or reject state guidance and, therefore, reimbursement as well.

VI. Instructional Methods and Devices[1] (Multi-Media)

Because we are involved in educating for life in a democratic society, it must be recognized that although the end results are important, the methodology or means involved in this process, which is ultimately measured in changed behavior, is almost overwhelmingly always the more important of the two. The end seldom justifies the means. Therefore, the following instructional methods and devices are presented:

A. Demonstrations
    1. Class
    2. Individual
    3. Group
B. Lectures
    1. Plain
    2. Illustrated

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[1] I. A Curriculum, Westport, CT, 1960, Revised 1970, p. 17, Drafting Section I. - 3rd Revision - 1982

It should be understood that any multi-media materials should not be used in lieu of the classroom teacher alone. These materials in any curriculum are both pertinent and vital in making any area of learning more enjoyable, vital, and adaptable to the students and their needs.

C. Discussion

  1. Group

  2. Individual

D. Printed Materials

  1. Textbook (s)

  2. Reference books

  3. Magazines

  4. Pamphlets

  5. Instruction sheets

    a. Operation

    b. Job

    c. Information

    d. Assignment

E. Field Trips

F. Motion pictures with projector

G. Film strips/slides: projectors/viewers (multi or individual) with or without sound capabilities

H. Transparencies with overhead projector

  1. Can be used for silhouette effect

  2. Can be used as secondary "chalk board"

I. Opaques/projector
    1. Illustrations
    2. Photos, etc.

J. Models

K. Diagrams

L. Dioramas

M. Charts, maps

N. Chalk boards

O. Bulletin boards
    1. Stationary
    2. Portable
    3. Magnetic

P. Empirical method

Q. Radio/Television (if and when possible)

R. Video/Tape[A]

S. Resource Personnel (especially local)

T. Records (disc)

U. Tape record/playback equipment

V. Closed circuit television

[A] Note: Above materials may be subjected to justification. The following items are intended for justification purposes: 1) Educational; 2) Special; 3) Informational

VII. Scoring Methods

The method of scoring will differ relative to the community and the existing educational philosophy. It may be one, or a combination of the following:

1. Numerical
2. Alphabetical
3. Narrative
4. Pass-Fail or No Record

Classwork, testing, and homework ought to enter into the gauging of an individual's progress - objective where pure A.E. information is required, and psychologically subjective where individual growth is concerned. In terms of the stated objectives compatible with the varied A.E. areas, the following are presented as tentative guides which will do the job if objective reporting is adhered to in terms of categorical subdivision.

A. Student Progress[A]

1. Projects (problem solving and assigned) 50% of grade
    a. Classroom use of time
    b. Homework achievement

[A] This interpretation will probably vary from teacher to teacher: it is suggestive only.

2. Related Work 10% of grade
    a. Testing (quizzes and exams)
    b. Research papers (report written/verbal presentation)
3. Shop Work[B] 20% of grade
    a. Proper use of shop
    b. Proper use of equipment
    c. Proper use of materials
4. Personal Achievement 20% of grade
    a. Cooperative (interest, leadership)
    b. Promptness (punctuality)
    c. Self-reliance (constructive judgment)
    d. Industry (drive, initiative, perseverance)
    e. Responsibility (dependability)
    f. Honesty (integrity - the Golden Rule)

VIII. Listing of Current Alternative Energy Reference Materials

Reference material breakdown as follows:

[B] Proper use - implies safe use

A. Methods

1. Audio-visuals
2. Teaching procedures and techniques viable in the solar field.
3. Trade and job analysis relative to the solar industry

B. Technical

1. All currently confirmed A.E. book publications
2. All current solar industry standards
3. All research done by Univ. of Saskatchawan, Canada on energy conservation
4. A.N.S.I. standards (American National Standards Institute)
5. European research particularly that of Prof. Felix Trombe, France.
6. All available research done by Israel-solar, the original source.
7. New Mexico solar energy assigned research
8. Audubon Society of Maine
9. Minnesota University underground housing
10. U.S. government printing office documents, etc.

C. Magazines

   1. Architectural
   2. Engineering
   3. Design
   4. Popular Engineering and Construction oriented[1]
   5. Professional journals
   6. Renewable energy

D. Pamphlets

   1. Research
   2. Analyses
   3. Dissertations

IX. Student Personnel Organization

In order to achieve a maximal teaching result, especially for this, our democratic society, student involvement ought to be actively sought and encouraged. Suggested is a breakdown which has proven to be effective in many I.A. class/lab situations, with the understanding that such layout, room size and shape are at the teacher's discretion.

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[1] These are: Popular Mechanics, Popular Science, Mechanix Illustrated, New Shelter, Country Journal, Mother Earth, among others yet to come.

A. Teacher: Not in front of the class, but on side where he/she can more effectively oversee the operations on a platform with lecture layout (table) and the chalk board will be above desk height and lecture layout table. This will permit full board viewing for all students. This could also be home base for all audio-visual use, as well as the light table center.

B. Class

1. Students to have revolving weekly responsibility assignments
2. Foreman[A] to be in charge of assuring smooth operation of above.

C. Cleanup

1. Students clean own work areas and properly store tools
2. Checked by foreman - - - (evaluated on daily basis subject to teacher review and evaluation)

[A] Note: Tools and equipment not belonging to the students ought to be centralized and available for student use when necessary. The suggestion is a responsibly controlled center which the Foreman operates, thus freeing the teacher for teaching.

VI. TEXT AND REFERENCE BOOK TITLES AUTHORS AND PUBLISHERS

A. The following list of Solar Publications was compiled by the U.S. Department of Housing and Urban Development in cooperation with the U.S. Department of Energy. It includes Periodicals, Directories, Books and Government Publications through May 1980. Due to changes and developments in solar energy, some information may be out of print or revised in new editions. More recent publications may be found in visiting the local library or book store. - - - 6 PP.

B. This information is from Alternative sources, i.e., books for general reference - - - 4 PP.

Non-Technical

THE COMPLETE GREENHOUSE BOOK...P. Clegg and D. Watkins; Garden Way Publishing, Charlotte, VT 05445, 1978, 280 pp., $8.95. Primarily a do-it-yourself guide, covers all aspects of greenhouses, including solar.

CONSUMER HANDBOOK OF SOLAR ENERGY...J. H. Keyes; Morgan and Morgan, Dobbs Ferry, NY 10522, 1979, 273 pp., $10.95. Guidelines for the person interested in purchasing a solar energy system; emphasizes "Solar Furnaces."

HOME GUIDE TO SOLAR HEATING AND COOLING...J. Hand; Harper & Row, New York, NY 10002, 1978, 183 pp., $3.95. A discussion of solar heating and cooling principles and a guide to installing solar energy systems.

HOME IMPROVEMENTS FOR CONSERVATION AND SOLAR ENERGY...F. Hickok; Hour House, St. Petersburg, FL 33743, 1977, 151 pp., $6.80. A guide to energy-efficient retrofitting techniques; includes solar energy systems.

HOW TO BUY SOLAR HEATING WITHOUT GETTING BURNT... M. Wells and I. Spetgang; Rodale Press, Emmaus, PA 18049, 1978, 262 pp., $6.95. A step-by-step method for determining whether solar heating is right for you; how to buy solar equipment without unnecessary expense.

HOW TO USE SOLAR ENERGY IN YOUR HOME AND BUSINESS... T. Lucas; Ward Ritchie Press, Pasadena, CA 91105, 1977, 250 pp., $7.95. A practical and basic guide to building and buying solar collectors; includes glossary, bibliography, and list of manufacturers.

PEOPLE WHO LIVE IN SOLAR HOUSES AND WHAT THEY SAY ABOUT THEM...C. Davis and M. Davis; Popular Library, New York, NY 10011, 1979, 224 pp., $2.25. Interviews with owners and occupants of 32 solar houses; includes costs, types of collectors and storage, and sketches of each house.

SOLAR AGE CATALOG...S. Oddo (ed); Solar Age, Church Hill, Harrisville, NH 03450, 232 pp., $8.50. A compilation of articles on all aspects of solar heating; includes comparative data tables of various types of collectors.

THE SOLAR AGE RESOURCE BOOK...M. McPhillips (ed); Everest House, New York, NY 10036, 1979, 242 pp., $9.95. A guide for the consumer to using solar energy in the home; includes articles and lists of manufacturers, dealers, etc.

THE SOLAR DECISION BOOK: YOUR GUIDE TO MAKING A SOUND INVESTMENT...R. H. Montgomery; Dow Corning Corporation, Midland, MI 48640, 1978, c250 pp., $10.00. A guide for everyone interested in solar, for consumers as well as distributors.

SOLAR ENERGY IN AMERICA...W. D. Metz and A. L. Hammond (eds); American Association for the Advancement of Sciences, Washington, DC 20005, 1978, 239 pp., $8.50. Articles, originally part of a series in Science, which give overviews of major solar energy technologies from power tower to ocean thermal energy.

SOLAR FOR YOUR PRESENT HOME...C. S. Barnaby, P. Caesar and B. Wilcox; California Energy Commission, 1111 Howe Ave., Sacramento, CA 95825, 1977, 163 pp., $4.00. A book on retrofitting from California that can be helpful in any part of the country.

THE SOLAR GREENHOUSE BOOK...J. C. McCullagh; Rodale Press, Emmaus, PA 18049, 1978, 328 pp., $8.95. All the basics of solar greenhouses, including designs, construction, and planting instructions.

SUN! A HANDBOOK FOR THE SOLAR DECADE...S. Lyons; Friends of the Earth, 124 Spear St., San Francisco, CA 94105, 1978, 364 pp., $2.75. Collected for the first SunDay; includes articles about various alternative energy sources.

THE SUN: OUR FUTURE ENERGY SOURCE...D. K. McDaniels; John Wiley & Sons, New York, NY 10016, 1979, 271 pp., $12.95. An introductory discussion of ways in which energy can be obtained from solar radiation.

SUN POWER: AN INTRODUCTION TO THE APPLICATIONS OF SOLAR ENERGY...J. C. McVeigh; Pergamon Press, Elmsford, NY 10523, 1977, 208 pp., $4.95. A state-of-the-art publication in non-technical language; covers all aspects of solar energy.

SUNSET'S HOMEOWNER'S GUIDE TO SOLAR HEATING... Sunset Books; Lane Publishing Co., Menlo Park, CA 94025, 1978, 96 pp., $2.95. An introduction to active and passive solar energy systems; includes photographs and drawings.

SURVEY OF THE EMERGING SOLAR ENERGY INDUSTRY... J. A. Bereny; Solar Energy Information Services, P.O. Box 204, San Mateo, CA 94401, 1977, 405 pp., $60.00. A comprehensive listing of names and addresses related to the solar industry; also an overview of the different facets of the industry.

YOUR SOLAR ENERGY HOME...D. Howell; Pergamon Press, Elmsford, NY 10523, 1979, 231 pp., $8.80. Written for homeowners in non-technical language; examples of solar water and space heating applications, including information about solar energy use in other countries.

Technical

BASICS OF SOLAR HEATING AND HOT WATER SYSTEMS... AIA Research Corp., Washington, DC 20006, 1977, 48 pp., $5.00. Design considerations important to the total system.

ENGINEER'S GUIDE TO SOLAR ENERGY...Y. Howell and J. A. Bereny; Solar Information Services, P.O. Box 204, San Mateo, CA 94401, 1979, 323 pp., $27.50. Both basic and advanced information on solar technology; includes various calculations for sizing a solar system.

PRINCIPLES OF SOLAR ENGINEERING...F. Kreith and J. F. Kreider; Hemisphere Publishing Corp., Washington, DC 20005, 1978, $24.50. The design and analysis of energy conversion systems; emphasis is on solar space and water heating systems.

SOLAR COLLECTOR DESIGN...D. K. Edwards; Franklin Institute Press, Philadelphia, PA 19103, 1977, 64 pp., $8.50. A technical discussion of the design and construction of solar components.

SOLAR ENERGY ENGINEERING...A. A. M. Sayigh (ed); Academic Press, New York, NY 10003, 1977, 506 pp., $36.00. A comprehensive and technical treatment of uses of solar energy; written by people experienced in solar engineering.

SOLAR ENERGY, TECHNOLOGY AND APPLICATIONS...J. R. Williams; Ann Arbor Science Publications, Inc., Ann Arbor, MI 48106, 1977, 120 pp., $6.95 (soft cover). A definitive overview of the various techniques for utilizing solar energy; includes glossary and comprehensive bibliography.

SOLAR HEATING DESIGN BY THE F-CHART METHOD...W. A. Beckman et al; John Wiley & Sons, New York, NY 10016, 1977, 200 pp., $14.95. A practical method for sizing solar space and water heating systems.

TOWARD A SOLAR CIVILIZATION...R. H. Williams (ed); The MIT Press, Cambridge, MA 02139, 1978, 251 pp., $12.50. Originally published in the Bulletin of the Atomic Scientists; 13 articles about the diverse applications of solar energy.

Architectural

AT HOME IN THE SUN: AN OPEN HOUSE TOUR OF SOLAR HOMES IN THE UNITED STATES...N. D. Davis and L. Lindsey; Garden Way Publishing, Charlotte, VT 05445, 1979, 236 pp., $9.95. Tours of 31 solar homes across the country; includes floor plans, technical data, interviews with owners, and more than 300 pictures.

THE COMPLETE SOLAR HOUSE...B. Cassiday; Dodd, Mead & Co., New York, NY 10016, 1977, 212 pp., $8.95. A discussion of the workings and functions of solar energy systems; includes the cost-savings features.

DESIGNING AND BUILDING A SOLAR HOUSE...D. Watson; Garden Way Publishing, Charlotte, VT 05445, 1977, 240 pp., $8.95. Practical, clearly written book which covers all aspects of solar house design, including siting, equipment, different types of systems, and costs.

NATURAL SOLAR ARCHITECTURE: A PASSIVE PRIMER... D. Wright; Van Nostrand, Reinhold Co., New York, NY 10001, 1978, 245 pp., $7.95. Comprehensive coverage of passive solar design; provides diagrams and explanations of important concepts.

THE PASSIVE SOLAR ENERGY BOOK...E. Mazria; Rodale Press, Emmaus, PA 18049, 1979, 435 pp., $10.95. A complete guide to passive solar building and greenhouse design; includes rules of thumb for system calculations.

SOLAR HEATED BUILDINGS OF NORTH AMERICA: 120 OUTSTANDING EXAMPLES...W. A. Shurcliff; Brick House Publishing Co., Harrisville, NH 03450, 1978, 295 pp., $8.95. Detailed descriptions of solar buildings in North America; all of the buildings are still in use; includes photographs of many.

SOLAR HOME BOOK...B. Anderson and M. Riordan; Brick House Publishing Co., 3 Main St., Andover, MA 01810, 1976, 297 pp., $7.50. Various aspects of solar home heating including direct and indirect systems, do-it-yourself solar water heating, retrofitting and social and cultural implications.

THIRTY ENERGY EFFICIENT HOMES YOU CAN BUILD...A. Wade and N. Ewenstein; Rodale Press, Emmaus, PA 18049, 1977, 316 pp., $8.95. Designs of houses already constructed presented for use by people building their own homes; solar designs included.

VILLAGE HOMES' SOLAR HOUSE DESIGNS...D. Bainbridge, J. Corbett and J. Hofacre; Rodale Press, Emmaus, PA 18049, 1979, 188 pp., $6.95. Illustrated with plans for 43 houses that are part of a solar community in Davis, CA; includes discussions of the solar energy systems, their performance and possible improvements.

General Energy

THE ENERGY CONTROVERSY: SOFT PATH QUESTIONS AND ANSWERS...A. Lovins; Friends of the Earth, 124 Spear St., San Francisco, CA 94105, 1979, 450 pp., $12.50. Explains the ideas behind soft energy paths and responds to those who have criticized these concepts.

ENERGY FUTURE: REPORT OF THE ENERGY PROJECT AT THE HARVARD BUSINESS SCHOOL...R. Stobaugh and D. Yergin (eds); Random House, New York, NY 10022, 1979, 353 pp., $12.95. A thorough study of the U.S. energy situation and our energy alternatives for the future; recommends courses of action including energy conservation and solar power.

HOME ENERGY HOW-TO...A. J. Hand; Harper and Row, New York, NY 10022, 1977, 258 pp., $9.95. Complete guide to saving and producing home energy.

INTRODUCTION TO APPROPRIATE TECHNOLOGY: TOWARD A SIMPLER LIFE STYLE...R. J. Congdon; Rodale Press, Emmaus, PA 18049, 1977, 205 pp., $6.95. A practical introduction to what could be the technology of the future; the story of appropriate technology from its beginnings to the present and some possibilities for the future.

PERSPECTIVES ON ENERGY: ISSUES, IDEAS, AND ENVIRONMENTAL DILEMMAS...L. C. Ruedisili and M. W. Firebaugh (eds); Oxford University Press, New York, NY 1978, 591 pp., $9.95. Thirty-five articles by leading energy experts dealing with such topics as fossil fuels, nuclear power and alternative energy sources.

THE POLITICS OF ENERGY...B. Commoner; Alfred A. Knopf, New York, NY 10022, 1979, 101 pp., $4.95. Discusses the national energy plan, its relationship to solar energy, and the uses of nuclear power and solar power.

SOFT ENERGY PATHS: TOWARDS A DURABLE PEACE... A. R. Lovins, Ballinger Publishing Co., Cambridge, MA 02138, 1977, 234 pp., $6.95. Proposals for restructuring of our energy system and steps to putting renewable energy into action.

STEPPING STONES: APPROPRIATE TECHNOLOGY AND BEYOND...L. deMoll and G. Coe; Schocken Books, New York, NY 10016, 1978, 204 pp., $7.95. Collection of articles which explores the beginnings of appropriate technology and goes on through what is presently happening and what may be beyond appropriate technology.

Directories

SOLAR ENERGY AND RESEARCH DIRECTORY...Ann Arbor Science Publishers, Inc., Ann Arbor, MI 48106, 1977, $22.50. A comprehensive directory of organizations involved in various aspects of solar energy technology.

SOLAR ENERGY SOURCE BOOK...C. W. Martz (ed); Solar Energy Institute of America, 1140 6th St. NW, Washington, DC 20001, 1978, 797 pp., $15.00. A guide to manufacturers and organizations; periodic updates provided to members.

SOLAR INDUSTRY INDEX...Solar Energy Industries Association, 1001 Connecticut Ave., NW, Ste. 632, Washington, DC 20036, 1978, 381 pp., $15.00. A comprehensive guide to manufacturers and service organizations; also includes chapter on operations and economics of solar energy systems.

SOLAR UPDATE...Environment Information Center, 124 E. 39th St., New York, NY 10016, 1977, $25.00. A guide to information sources in solar energy.

Periodicals

ALTERNATIVE SOURCES OF ENERGY...Alternate Sources of Energy, Inc., Route 2, Box 90A, Milaca, MN 56353, Quarterly, $10.00/yr. Articles, columns and features on many aspects of energy alternatives; serves as a clearinghouse for exchange of ideas and technologies.

HOME ENERGY DIGEST AND WOOD BURNING QUARTERLY... Home Energy Digest, Division of Investment Rarities, Inc., 8009 34th Ave., South, Minneapolis, MN 55420, Quarterly, $7.95/yr. Features articles and columns on home heating and energy conservation; includes solar and other energy alternatives.

THE MOTHER EARTH NEWS...The Mother Earth News, Inc., 105 Stoney Mountain Road, Hendersonville, NC 28739, Bi-monthly, $12.00/yr. Down-to-earth descriptions of peoples' experiences with alternative lifestyles, ecology and energy; source for what is happening in energy at the grass roots level.

SOLAR AGE...Solar Vision, Inc., Church Hill, Harrisville, NH 03450, Monthly, $20.00/yr. Brief articles on developments in solar energy applications, with emphasis on solar heating and cooling.

SOLAR ENERGY...Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, NY 10523, Monthly, $121.00/yr. (Included with membership in International Solar Energy Society - $40.00). Scientific and engineering papers on all aspects of solar energy and technology, theory, and applications.

SOLAR ENERGY INTELLIGENCE REPORT...Business Publishers, Inc., P.O. Box 1067, Silver Spring, MD 20910, Weekly, $90.00. The Washington beat in solar energy; also new developments, markets, meetings.

SOLAR ENGINEERING...Solar Engineering Publishers, Inc., 8435 N. Stemmons Freeway, Suite 880, Dallas, TX 75247, Monthly, $15.00/yr. Short descriptions of activities and developments in the field of solar energy, particularly in the private sector of the U.S.

SOLAR HEATING & COOLING...Gordon Publications, P.O. Box 2126-R, Morristown, NJ 07960, Monthly, $8.00/yr. Short articles on solar heating and cooling issues, developments, and equipment; oriented to builders, developers, and manufacturers.

Government Publications

APPLICATION OF SOLAR TECHNOLOGY TO TODAY'S ENERGY NEEDS...Office of Technology Assessment; Stock No. 052-003-00539-5, GPO, 1977, $7.00. Assessment of the implications of large scale use of on-site solar energy in the frame work of the total energy problem.

BUYING SOLAR...Federal Energy Administration; Stock No. 041-018-00120-4, GPO, June 1976, 71 pp., $1.85. A guide to factors a homeowner should consider when buying solar systems.

THE FIRST PASSIVE SOLAR HOME AWARDS...Franklin Research Center, Stock No. 023-000-00571-4, GPO, 1978, $5.50. Written for architects and others interested in passive solar design; overview of designs selected for awards in the Passive Design Competition.

A GUIDE TO FEDERAL PROGRAMS OF POSSIBLE ASSISTANCE TO THE SOLAR ENERGY COMMUNITY...Congressional Research Service; Stock No. 052-070-04080-7, GPO, 1977, $4.00. Report on existing programs which provide help to individuals and organizations interested in using solar energy.

HUD INTERMEDIATE MINIMUM PROPERTY STANDARDS SUPPLEMENT: SOLAR HEATING AND DOMESTIC HOT WATER SYSTEMS...Order No. 4930-2, GPO, 1977, $12.00 (including updates). Solar requirements and standards applicable to one- and two-family dwellings, multifamily housing, and nursing homes and intermediate care facilities.

INSTALLATION GUIDELINES FOR SOLAR DHW SYSTEMS IN ONE AND TWO FAMILY DWELLINGS...Franklin Research Center; Stock No. 023-000-00520-4, GPO, 1979, 111 pp., $4.00. Written for the professional installation contractor and the skilled homeowner. Along with installation instructions, gives pointers for maintenance and installation checklists.

REGIONAL GUIDELINES FOR BUILDING PASSIVE ENERGY CONSERVING HOMES...AIA Research Corp.; Stock No. 023-000-00481-0, GPO, 1978, 312 pp., $5.25. An aid to architects and others who are considering using passive solar and energy-conserving design.

SOLAR DWELLING DESIGN CONCEPTS...AIA Research Corp.; Stock No. 023-000-00334-1, GPO, May 1976, 136 pp., $2.30. Discussion of all facets of the design and siting of housing intended to be heated by the sun; also includes discussion of the impact of solar energy utilization on traditional dwelling design.

SOLAR ENERGY IN AMERICA'S FUTURE: A PRELIMINARY ASSESSMENT...Energy Research and Development Administration; Stock No. 060-000-00051-4, GPO, March 1977, 104 pp., $2.00. Documentation of a Stanford Research Institute study of the potential roles that solar energy technologies could have for meeting U.S. energy needs over the next 45 years.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM: A DESCRIPTIVE SUMMARY OF HUD CYCLE 3 SOLAR RESIDENTIAL PROJECTS, SUMMER 1977...AIA Research Corp.; Stock No. 023-000-00418-6, GPO, 1977, 165 pp., $3.50. The projects selected from the grant applications for the third cycle in the HUD solar heating and cooling demonstration program; sketches of buildings included.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM: A DESCRIPTIVE SUMMARY OF HUD CYCLE 4 AND 4A SOLAR RESIDENTIAL PROJECTS...AIA Research Corp.; Stock No. 023-000-00531-0, GPO, 1979, $4.75. Solar grant projects selected for Cycle 4 and 4A awards in the HUD Solar Heating and Cooling Demonstration Program; includes drawings of buildings and solar systems.

SOLAR HEATING AND COOLING DEMONSTRATION PROJECT SUMMARIES...Department of Energy; Stock No. 061-000-00082-8, GPO, 1978, $4.50. Brief descriptive overview of solar heating and cooling demonstration projects funded by DOE through 1977.

SOLAR HEATING AND COOLING RESEARCH AND DEVELOPMENT PROJECT SUMMARIES...Department of Energy; Stock No. 061-000-00072-1, GPO, 1978, $5.00. Summaries of research and development projects in the areas of collectors, thermal energy storage, solar heat pumps, solar cooling and controls funded through 1977.

SOLAR PROGRAM ASSESSMENT: ENVIRONMENTAL FACTORS - SOLAR HEATING AND COOLING OF BUILDINGS...Energy Research and Development Administration; Stock No. 060-000-00060-3, GPO, March 1977, 76 pp., $2.20. Presentation of the environmental issues associated with the further development of solar heating and cooling.

A SURVEY OF PASSIVE SOLAR BUILDINGS...AIA Research Corp.; Stock No. 023-000-00437-2, GPO, 1978, 177 pp., $3.75. Descriptions of a variety of passive solar buildings, including direct gain, indirect gain, and isolated gain; passive cooling is also presented.

** Government publications are available from GPO. They can be obtained by writing: Superintendent of Documents, Government Printing Office, Washington, DC 20402. Use the stock no. when ordering. The other materials are NOT available through the National Solar Heating and Cooling Information Center. They can be obtained by contacting the publishers, bookstores, or local libraries. This Reading List represents only a portion of the material available on solar energy. The book and pamphlet holdings of the National Solar Center library are available upon request.

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VII. ALTERNATIVE SOURCES

BIBLIOGRAPHY OF SOLAR TEACHING AIDS

Books for General Reference

Blueprint for Survival, edited by The Ecologist.
(New American Library, 120 Woodbine St., Bergenfield, NJ 07621, 1972, $1.50/paper.)

Brown's Alcohol Motor Fuel Book, M. H. Brown.
(Desert Publishers, Star Route, Box 1935, Cornville, AZ 86325, 1979, $9.95.)

Consumer Handbook of Solar Energy, John H. Keys.
(Morgan & Morgan, 145 Palisades St., Dobbs Ferry, NY 10522, 1979, $10.95/paper.)

Direct Use of the Sun's Energy, Farrington Daniels.
(Ballentine Books, 210 East 50th St., New York, NY 10022, 1974, $1.95/paper.)

Energy: A Crisis, A Dilemma, Or Just Another Problem?, Jesse S. Doolittle. (Matrix Publishing Co., 27 Benefit St., Providence, RI 02904, 1977, $12.95/paper.)

Energy and Order, Mark Terry & Paul Witt.
(Friends of the Earth, Inc., 124 Spear, San Francisco, CA 94105, 1976, $3.00/paper.)

Energy Book I and II, edited by John Prenis.
(Running Press, 38 South 19th St., Philadelphia, PA 19103, 1977, $5.00/paper.)

Energy, New Low Cost Sources for the Home, Peter Clegg.
(Garden Way Publishing Co., Charlotte, VT 05445, 1975, $7.95/paper.)

Energy Primer, Richard Merrill et al.
(Portola Institute, 558 Santa Cruz Ave., Menlo Park, CA 94025, 1975, $5.50/paper.)

Energy Savers Catalog, editors of Consumer Guide.
(G. Putnam's Sons, 1050 Wall St., West Lyndhurst, NJ 07071, 1977, $6.95/paper.)

Engineer's Guide to Solar Energy, Yvonne Howell & Justin A. Bereny.
(Solar Energy Information Services, 18 Second Ave., P.O. Box 204, San Mateo, CA 94401, 1979, $29.50/paper.)

The Fuel Savers: A Kit of Solar Ideas for Existing Homes, Dan Scully et al. (Brick House Publishing Co., 3 Main St., Andover, MA 01810, 1978, $2.75/paper.)

Handbook of Homemade Power, Mother Earth News Staff.
(Bantam Books, 666 Fifth Ave., New York, NY 10019, 1974, $2.95/paper.)

Harnessing Water Power for Home Energy, Dermot McGuigan.
(Garden Way Publishing Co., Charlotte, VT 05445, 1978, $4.95/paper.)

Home Energy for the Eighties, Ralph Wolfe and Peter Clegg.
(Garden Way Publishing Co., Charlotte, VT 05445, 1979, $10.95/paper.)

Homeowner's Guide to Solar Heating, Sunset Books.
(Lane Publishing, Willow & Middlefield Roads, Menlo Park, CA 94025, 1979, $3.95.)

How to Build the Michigan Airtight Stove, S. S. Miner.
(Miner Machine Developing Co., 1411 Harrah Road, Niles, MI 49120, 1978, $5.00.)

In the Bank Or Up the Chimney?
(Chilton, School Library Services, 201 King of Prussia Rd., Radnor, PA 19089, 1976, $1.95/paper.)

Introduction to Appropriate Technology, R. J. Congdon.
(Rodale Press, 33 East Minor St., Emmaus, PA 18049, 1977, $6.95/paper.)

Limits to Growth, Donella H. Meadows et al.
(Signet - New American Library, 120 Woodbine St., Bergenfield, NJ 07621, 1972, $1.50/paper.)

New Inventions in Low Cost Solar Heating, William A. Shurcliff.
(Brick House Publishing Co., 3 Main St., Andover, MA 01810, 1979, $12.00/paper.)

100 Ways to Save Energy & Money in the Home, Office of Energy Conservation. (Conservation Books, P.O. Box 3500, Sta. C, Ottawa, Ontario, Canada K1Y 4G1, 1979, free.)

Other Homes and Garage, Jim Leckie et al.
(Sierra Club Books, 530 Bush St., San Francisco, CA 94108, 1975, $9.95.)

The Passive Solar Energy Book, Edward Mazria.
(Rodale Press, 33 East Minor St., Emmaus, PA 18049, 1979, $12.95/paper.)

Practical Building of Methane Power Plants for Energy Independence, L. John Fry. (L. John Fry, 1223 North Nopal St., Santa Barbara, CA 93103, 1974, $12.00/paper.)

Rainbook: Resources for Appropriate Technology, editors of Rain.
(Schocken Books, Inc., 200 Madison Ave., New York, NY 10016, 1977, $7.95/paper.)

Rays of Hope, Denis Hayes.
(W. W. Norton, 500 Fifth Ave., New York, NY 10036, 1977, $3.95/paper.)

Simplified Wind Power Systems & Experiments, Jack Paar.
(Helion Corp., Box 445, Brownville, CA 95919, 1975, $6.00.)

Small is Beautiful: Economics As If People Mattered, E. F. Schumacher. (Harper Row, Keystone Industrial Park, Scranton, PA 18512, 1975, $2.95/paper.)

Soft Energy Paths: Towards a Durable Peace, Amory B. Lovins. (Harper Row, Keystone Industrial Park, Scranton, PA 18512, 1979, $3.95/paper.)

Solar Age Resource Book, editors of Solar Age. (Everest House, 1133 Avenue of the Americas, New York, NY 10036, 1979, $9.95/paper.)

Solar Cells & Photocells, Rufus T. Turner. (Howard W. Sams & Co., Inc., 4300 West 62nd St., Indianapolis, IN 46206, 1980, $4.95/paper.)

Solar Energy Series, I, II, III, William H. Rankins, III, & David A. Wilson. (Lorien House, P.O. Box 1112, Black Mountain, NC 28711, 1976, $4.00.)

Solar Workbook. (New York State Energy Office, 2 Rockefeller Plaza, Albany, NY 12223, Attn: Solar Workbook, 1980, Free.)

Sun/Earth, Richard Crowther. (Scribner & Sons, 597 Fifth Ave., New York, NY 10017, 1978, $8.95/paper.)

Sunspots, Steve Baer. (Zomeworks Corp., P.O. Box 712, Albuquerque, NM 87103, 1977, $4.00/paper.)

Survival Scrapbooks 1-2-3, Stefan A. Szczelkun. (Schocken Books, Inc., 200 Madison Ave., New York, NY 10016, 1973, $3.95/paper.)

Village Technology Handbook. (VITA, 3706 Rhode Island Ave., Mount Rainier, MD 20822, contact VITA for price.)

Wind & Windspinners, Michael A. Hackleman. (Peace Press, Inc., 3828 Willat Ave., Culver City, CA 90230, $8.95/paper.)

Wind Power for Farms, Homes, & Small Industry, Jack Paar & Dick Schwind. (Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, 1978, $9.25/paper.)

Wood Heat, John Vivian. (Rodale Press, 33 East Minor St., Emmaus, PA 18049, 1978, $7.95/paper.)

Books for Students

Solar Fun Book, John Barling. (Brick House Publishing Co., 3 Main St., Andover, MA 01810, 1980, $7.95.)

Solar Energy: Solar Education for the 80's, Frank Jenkins et al. (J.M. LeBel Enterprises Ltd., 10372-60 Ave., Edmonton, Alberta, Canada T6H 1G9, 1980, contact publisher for prices.)

Solar Energy Experiments, Thomas W. Norton. (Rodale Press, 33 East Minor St., Emmaus, PA 18049, 1977, $5.95.)

Solar Energy Laboratory Manual, W. Douglas Davis. (Crystal Productions, Box 11480, Aspen, CO 81611, 1979, $5.95.)

Solar Science Projects, D. S. Halacy, Jr. (Scholastic Book Services, 50 West 44th St., New York, NY 10036, 1974, $.85.)

Magazines and Newsletters

Alternative Sources of Energy (107 South Central Avenue, Milaca, MN 56353, $16.50/year.)

Current Energy & Ecology
(Curriculum Innovations, Inc., 3500 Western Ave., Highland Park, IL 60035, $3.95/year per student.)

Energy & Education
(National Science Teachers Assoc., 1742 Connecticut Ave., Washington, DC 20009, free.)

Energy Consumer
(DOE Office of Consumer Affairs, Room 8G082, Washington, DC 20585, free.)

Energy Insider
(Mail Stop, 8G031, Washington, DC 20585, free.)

Harrowsmith
(Camden House Publishers, Camden East, Ontario, Canada KOK 1JO, $10.00/year.)

Home Energy Digest
(8009 34th Avenue South, Minneapolis, MN 55420, $7.95/year.)

New Shelter
(Rodale Press, 33 East Minor St., Emmaus, PA 18049, $9.00/year.)

Popular Science
(Box 2871, Boulder, CO 80302, $11.94/year.)

Solar Age
(P.O. Box 4934, Manchester, NH 03108, $20.00/year.)

Solar Energy Digest
(William B. Edmondson, Box 17776, San Diego, CA 92117, $38.00/year.)

Solar Engineering Magazine
(G.P.O., Box 1736, Brooklyn, NY 11202, $20.00/year.)

Solar Heating & Cooling
(Gordon Publications, Box 2106R, 20 Community Place, Morristown, NJ 07960, $8.00/year.)

VIII. TOOLS AND EQUIPMENT

I. General Items

2-Storage cabinets*, 36" x 24" x 78", double door/lock, welded frame construction, four shelves

1-Storage cabinet*, 36" x 24" x 78", combination supplies and clothing compartment, double door/lock, welded frame construction, four adjustable shelves, and clothes bar

2-Storage racks, vertical, wood or metal, all purpose, 48" x 34" x 108", metal construction triangular shape, 8 shelves with partitions

1-Hardware cabinet, 36" x 12" x 78", with assorted size drawers and bins, double door, master keyed lock

2-Apron and book racks*, 36" x 12" x 39", steel, 9 compartments

1-Stock cart, 30" x 24" x 32", steel construction, four 5" rubber wheels, with middle shelf

1-Safety glass and goggle cabinet, assorted glasses, sanitation capability, capacity for 24

1-Standup teacher's desk and draftsman's chair*; desk - 36" x 30" x 52", steel construction, drawer, shelf; chair - adjustable 26" to 34", foam seat (a drawing table may be substituted)

1-File cabinet*, 3-drawer, legal size, 15" x 30" x 26" deep, steel

1-Bookcase*, 12" x 36" x 60", two flat shelves, two sloping shelves

1-Overhead projector*, 500 watt, 10" x 10" stage

1-Projector cart*, 18" x 24" x 34", storage cabinet, shelf, 110 v outlet

1-Planning table*, 24" x 60" x 30" high, steel construction, open legs, 1¼" plastic top

8-Tool panels, approximately 30" x 36", punched steel, mounting strips, holes 1" o.c., bolt-type tool shelves and holders

1-Shop vacuum, 10 gallon steel drum, 2½" hose, assorted nozzles, casters

1-Sink, porcelain, wall type, 3 mixer-type faucets, clay trap

24-Tote trays, 13" x 4", plastic, cardholders

12-Brushes, counter, 8"

4-Brooms, push, 18"

2-Dustpans, 12"

2-Waste cans, 20 gallon, casters

20-Stools, 24" high, foot ring, steel

1-Storage cabinet for flammables

1-Dust collection system, with funnel attachments for lathes, sanders, saws, etc., motor unit outside shop, under floor ductwork

4-Drop cord electric outlets, reel type, mounted over work benches

1-Radial arm saw, 10" capacity, 1½ hp motor, controls, cabinet base, dust collector funnel, guards, extra blades, on rubber machine mounts

4-Work benches, 2¼" flat laminated maple top, 54" x 64", equipped with 4 woodworker's vises, horizontal steel locker base

1-Finishing bench, double door cabinet base, steel construction, 6' x 24" x 33" high, 2" enameled steel top

1-Glue bench, 6' x 24" x 33" high, 2" galvanized steel top, double door cabinet base, steel construction

1-Circular saw, floor model, 10" complete with all basic parts, guards, fences, miter gauge, switch, magnetic starter, enclosed cabinet base, dust funnel, motor cover and 1½ hp motor, mounted on rubber machine mounts, with blade assortment

1-Dado head set, 13/16" wide x 6" diam., with table insert

1-Scroll saw, 24" throat, mounted on floor stand, 4-speed model, including belt guard, motor and motor control, mounted on flexible rubber machine mounts, saber blade attachment

1-20" band saw, wood cutting, sealed ball bearings, 45° tilt table, dust funnel, motor and control, on rubber mounts

1-Sander-grinder, 1" x 48" abrasive belt, motor, control, stand, on rubber mounts

1-1¼" router, portable, ¼" collect cap., trigger switch, carbide cutter set, plastic laminate trimmer

1-Sander, portable belt, 4" x 24", trigger switch, with dust collector

1-Uni-plane, 6" cut cap., 8 cutters, guards, motors, control dust funnel, chip deflector, on rubber mounts

1-Sander, 6" abrasive belt finishing machine complete with enclosed steel stand, table, guards, motor, miter gauge, back stop, dust funnel, mounted on flexible rubber machine mounts

2-Portable orbital or straight line finishing sanders, heavy duty, 2.3 amp minimum, sanding area approximately 4½" x 11", dust collector attachment

1-Saber saw, heavy duty, minimum 2.5 motor amps, idle speed minimum approximately 4,000 SPM, 7/16" minimum stroke, ball or needle bearings

1-Electric hand drill, heavy duty, minimum 2.7 amps, slow speed, 3/8" chuck, with screwdriver and reversing switch

1-6" jointer, 7" x 42" table, 2-way tilt fence with enclosed stand, motor, controls, guards, dust funnel on rubber mounts

1-Grinding wheel dresser

3-Awls, scratch

1-Bit, auger set, nos. 4 to 16 by 16ths

2-Bits, dowel, size no. 4

2-Bits, dowel, size no. 6

1-Bit, expansive 7/8" to 1½"

5-Bits, multi-spur machine, wood, ½" shank, one each size 3/8", ½", 5/8", 3/4", 1"

4-Bits, screwdriver, set 3/16" to 3/8"

1-Bit, spade, set of 6, sizes 3/8", ½", 5/8", 3/4", 7/8", 1"

6-Braces, ratchet, 8" swing, self-centering chuck

2-Calipers, outside, 6"

2-Calipers, inside, 6"

1-Chisel, set, heavy duty, one-piece blade and shank, plastic handle, 1/8" to 1"

4-Clamps, miter and corner, 3" capacity, multi-purpose, swing pivot

6-Clamps, carriage 3" opening, 2¼" throat depth

6-Clamps, carriage 6" opening, 3¼" throat depth

4-Clamps, carriage 8" opening, 3-3/4" throat depth

6-Clamps, I-bar, 3', 2/6", 8", 10"

4-Clamps, I-bar, 6'

6-Clamps, hand screws, 6" jaw length, size no. 3/0

6-Clamps, hand screws, 10" jaw length, size no. 1

6-Clamps, spring, 3" capacity, steel, multi-purpose

1-Clamp, web

1-Container, oily waste, 10 gal.

2-Countersinks, wood, ½" x 82^{0} square shank brace type

2-Countersinks, metal, 3/4" x 82^{0} straight shank, high speed

2-Dividers, wing 10"

1-Drill set, H.S. steel, 1/16" to ½" by 32nds

1-Drill stand, aluminum, for drills 1/16" to ½" by 32nds

1-File, auger bit

1-File, cabinet 8'

1-File, flat wood, 14"

10-Round files, 5 - 8" & 5 - 12", wood

6-Files, half round wood, 10"

2-File cards, with brush, 10" overall

1-Gauge, bit, spring type

2-Gauges, marking, metal

6-Hammers, nail, 3/16 oz., & 3/20 oz.

2-Hammers, nail, 13 oz.

1-Hammer, ripping, 16 oz.

2-Hand drills, 3/8" capacity, enclosed gears

12-Handles, file, to fit 10" files

2-Jigs, doweling, self-centering style

2-Knives, utility

2-Mallets, white rubber, 3 3/4" x 2¼"

2-Mallets, rawhide, 2" x 3½"

2-Miter boxes, 26" x 4" saw, 8¼" right angle capacity

4-Nail sets, one each size 1/32", 1/16", 3/32", and 1/8"

1-Oilstone, combination coarse and fine, India, 6" x 2" x 1"

1-Oilstone, box, metal, to fit stones 6" x 2" x 1"

1-Oilstone, gouge slip, India

2-Planes, block, 6" long, 1-5/8" blade, adjustable throat

2-Planes, smooth, 8" long, 1 3/4" cutter

2-Planes, jack, 14" long, 2" cutter

1-Hole saw, 7 blades, 1" to 2½" cap.

3-Push drills, complete with set of 8 drill points

1-Rasp, cabinet, 10" - 12"

1-Rasp, round wood, 10"

1-Shoe rasp, 10"

3-Levels, aluminum, 4 vial, 1/24" & 2/36"

6-Rules, steel, 12", M/E

4-Rules, steel, 24", M/E

2-Rules, steel, 1m, M/E

4-Rules, tape, 3/4" spring steel blade, 2/12", 10', M/E

1/50' tapes - steel tapes also

1/100' steel - steel tapes also

3-Saws, back, 12", 18", 20"

2-Saws, hand, 24", 12 point crosscut

2-Saws, hand, 24", 8 point rip

2-Saws, coping frames, 6 3/4" depth, 6½" pin end blades

26-Screwdriver assortment, 30 pieces, assorted sizes and types, plastic handles, alloy blades

1-Screw mate, set of 10, drill and countersink combination, assorted sizes

6-Replacement blades

1-Surform style tool, flat file type

1-Surform style tool, half round blade

1-Surform style tool, round file type

2-Staple guns, heavy duty

2-Squares, try, 6" blade, M/E

1-Square, try, 12" blade, M/E

2-Squares, try and miter, 8" blade, M/E combo

1-Square, framing, 24", steel, rafter table, M/E

1-Wrench, adjustable, 4"

1-Wrench, adjustable, 6"

1-Wrench set, combination box and open end, 3/8" to 3/4" by 1/16"

6-Pliers, vise grip, 8"

1-Pliers, side cutting, 7"

1-Pliers, multiple rib joint, 10"

1-Pliers, slip joint, 8"

1-Pliers, diagonal cutting

2-Shears, heavy duty, 8" x 2½" cut

1-Sander, drum, 2¼" x 3" sleeve

1-Sander, flex wheel, 5½" x 1", ½" shaft

II. Tools, Furniture and Equipment

A. Tools

1-Perspective drawing board 24" x 30"

1-Compass, small bow, 8" capacity

1-Compass, large bow, 12" capacity

1-Scale, triangular, architect's

1-Scale, triangular, engineer's

1-Scale, Metric

1-Triangle, 45°, 8"

1-Triangle, 60°, 10"

1-Irregular Curve set

1-Draftsman's duster

1-Technical fountain pen with point set

1-Template set, circle, ellipse, radius guide

1-Compass, beam, 13"

4-Erasing shields

2-Surveyor's level/transit, tripod, ¼" ca. 100' accuracy

1-T-Square, 24", aluminum

1-Drawing board, 20" x 26", metal edges

1-Arrow set, surveyor's

6-Hand levels, accuracy to 100 yards

6-Compasses, hand, 360° N-S

2-Surveyor's chains, 100'

2-Tape rules, 200', M/E

1-Rotary knife trimmer, 24"

B. Furniture and Equipment

1-Drawing table 24" x 32" plastic top, 7° fixed angle, 8-drawer base unit mounted

2-Metalworking benches, 54" x 64", 2" wood core with 12-gauge folded steel top, 32" high, 12 horizontal locker base cabinet, equipped with 4 stationary base machinist's vises, 3" jaw width

1-Metalworking bench, 24" x 72" x 33" high, 2" wood core with folded 12-gauge steel top, equipped with two stationary base machinist's vises, 3½" knurled face jaw width, combination 8-drawer and double door cabinet base

1-Soldering bench, 6' x 24" x 33" high, steel top covered with transite, steel construction, combination 8-drawer and double door cabinet base, 10½" x 12" x 72" riser shelf, adjustable vise

1-Finishing bench, 6' x 24" x 33" high, steel double door cabinet base, enameled steel top

1-Drill press, 15" floor, variable speed, tilt table, 3/4 hp, controls ½" chuck, guards, vise, tool tray

1-Anvil, 50 lb., anvil stand on rubber mounts, tongs

1-Air compressor, 1 hp, twin cylinder, 20 gal. tank, delivery 5 cfm at 100 psi, filter, regulator, cleaning gun, tire chuck, two 25' hoses, quick couplers

1-Abrasive cabinet, 13" x 24" opening, dust collector, portable gun, hose

1-Stake plate, steel stand, steel stake assortment

1-Squaring shear, 36", foot treadle, 16-gauge capacity

1-Box and pan brake, 24", 16-gauge capacity, steel stand

1-Drill, electric, hand, 3/8" geared chuck, 500 rpm, heavy duty

1-Drill, electric, hand, ¼" chuck, heavy duty

1-Grinder, 7", motor, controls, safety shields, lights, guards, cabinet base

1-Buffer, long shaft, ½ hp motor, controls, 8" wheels, eye shields, cabinet base

1-Metal bandsaw, vertical-horizontal, 3-speed, work table, capacity 7" x 11", motor, controls, self stand

1-Disc grinder, 7" pad, 4000 rpm, ball bearings, 110 v

1-Arc welder, 40-225 amp range, cables, clamps, electrode holder, welding helmet, gloves, hammer

1-Arc/gas welding bench, two-station, back and side curtains, storage, steel top

1-Gas welding outfit, two-stage regulators, tip assortment, cutting attachment, hose, goggles, accessories, welding clamps, gloves

1-Gas welding cylinder cart, for 9" cylinders, 10" x 2.75" wheels, safety chains

6-Welding hand shields, replacement lenses

1-Bar folder, 30", 20-gauge capacity, steel stand

1-Rotary machine, combination with roll assortment

1-Slip roll, 30", 22-gauge capacity, steel stand

1-Metal punch, hand, 2" hole - 14-gauge capacity, 7" throat

1-Hydraulic shear, hand, ½" x 2" capacity

1-Bender, bar and tubing, hand, cabinet base, capacity
6" rad. x ½" tubing

4-Awls, scratch, wood handle

6-Awls, ring scratch, 8½" long

1-Calipers, inside, spring style, 4"

1-Calipers, outside, spring style, 6"

1-Center head, 12" rule, M/E

2-Chisels, cape, ½" hexagon

2-Chisels, cold, 3/8", hexagon

2-Chisels, cold, ½", hexagon

4-Clamps, carriage, 3" opening

2-Clamps, carriage, 6" opening

2-Clamps, carriage, 10" opening

12-Clamps, carriage, 1½" opening

6-Clamps, spring, 3/4" maximum opening, 4" jaw length

6-Clamps, spring, 1½" maximum opening, 6" jaw length

2-Countersinks, ½" body, 3/8" shank, high speed

2-Countersinks, 3/4" body, ½" shank, high speed

3-Dividers, 6" spring type

1-Divider, wing, 8"

2-Drill sets, high speed, 1/16" to ½" by 64ths

1-Drill set, letter sizes

1-Drill set, high speed, wire gauge sizes

1-Drill set, high speed, metric sizes to 15mm

1-Drill extractor set, 1-9

1-Drill stand, aluminum, for drills to ½" by 64ths

24-Files, assorted shapes and cuts, 10" and 12"

24-File handles, to fit 10" and 12" files

4-File cards, 10" with brush

2-Gauges, center

2-Gauges, sheet metal, U.S. standard sizes 0 to 36

2-Gauges, drill, 1/16" to ½" by 64ths

2-Hammers, ball peen, 8 oz.

4-Hammers, ball peen, 12 oz.

4-Hammers, ball peen, 16 oz.

2-Lead hammers, 1 lb., with mold

2-Hammers, tinner's riveting, 12 oz.

2-Hammers, tinner's setting, 12 cz.

2-Mallets, plastic, 16 oz.

2-Jigs, metal bending, complete with base

4-Mallets, maple, 2½" x 3" x 6"

1-Nibbling tool, hand held, 18-gauge capacity

1-Nipper, end cutting 6"

1-Nipper, wire, 10" wide with double-edge replaceable jaw

1-Oily waste can, 10 gal. capacity

2-Pliers, side cutting, 6"

2-Pliers, combination, 6"

2-Pliers, needle nose, 6"

2-Pliers, short flat nose, 6"

1-Pop rivet gun, 1/8" standard, interchangeable heads

1-Punch and chisel set, 12 assorted

4-Hacksaws, adjustable, 10" - 12", closed plastic handle

1-Screwdriver, set, Phillips, plastic handle

2-Screwdrivers, 4" blade, standard tip, plastic handle

2-Screwdrivers, 6" blade, standard tip, plastic handle

1-Screwdriver, 8" blade, standard tip, plastic handle

1-Screwdriver, 10" blade, standard tip, plastic handle

1-Hole saw set, 3/4" to 2½" cap., arbors, extension

2-Scribers, ¼" x 2 3/8"

7-Sets, rivet, 2 through 8

3-Snips, tin, straight cut, 3" cut

1-Snips, curved blade, 3" cut

2-Snips, combination, 3" cut

2-Snips, aviation, straight

4-Squares, steel, 12" x 8", M/E

1-Square, steel, polished body, 24" x 2", tongue 16" x 1", M/E

6-Squares, combination, 12" steel blade, adjustable, center head, M/E

4-Soldering irons, electric, ½" tip diameter

1-Soldering iron, electric, 7/8" tip diameter

2-Soldering guns, electric, 250 watt

2-Torches, propane, assorted tips

1-Wrench, adjustable, 4"

1-Wrench, adjustable, 6"

1-Wrench, adjustable, 8"

1-Wrench set, combination box and open end, openings from 3/8" to 3/4" by 16ths

2-Wrenches, pipe, 10"

1-Pipe cutter, 2" capacity

1-Pipe flaring tool 3/16" to 3/4" O.D.

1-Pipe vise, 2" capacity

1-Micrometer, outside, 3"

1-Micrometer, outside, 2"

1-Micrometer, outside, 1"

1-Micrometer, cutside, 5cm metric

1-Vernier caliper, 5", inside-outside jaws, 1/128 scale, M/E

1-Tap and die set, national coarse

1-Tap and die set, national fine

1-Tap and die set, pipe

1-Tap and die set, metric, to 12mm

1-Hand punch, #5, 1 3/4 throat with punches - dies and bench mount

1-Gauge, thickness, 9 leaf

12-Drill countersinks

1-Reamer, center, set, to ½"

1-Reamer, taper

1-Reamer, burring

1-Hand seamer, 3½"

1-Tap and drill gauge, 1-60

2-Socket wrench sets, 3/8" drive, ¼" to 7/8", attachments

2-Socket sets, ½" drive, 3/8" to 1½", attachments

1-Socket set, ½" drive, 12 pt. deep sockets, ½" to 1"

6-Wrenches, pipe, 10", 14", 18"

2-Wrench sets, Allen, 11 hex keys

1-Wrench set, Allen, metric

1-Wrench set, midget offset box, 3/16" to 3/8"

1-Hoe, 6" blade, 12" handle

2-Trowels, pointing

4-Concrete tools, edgers, floats, assorted

1-Mortar pan, 30" x 30", steel

III. Tools and Materials

On site tools and materials needed to install a closed solar loop: Hot Water System

A. Tools

1. Pipe cutter or hacksaw, fine tooth
2. Plumbers level
3. File, fine
4. Hammer
5. Set of standard pliers
6. Set of channel lock pliers
7. 14" pipe wrench

8. 8" or 10" crescent wrench
9. 3/8" drive socket set
10. Cross cut hand saw
11. Caulking gun
12. 100' grounded extension cord
13. Acetylene torch or M.A.P. torch
14. Flint striker
15. Measuring tape
16. Tooth brush
17. Workgloves
18. Rags
19. Safety goggles
20. Scissors
21. Electric drill
22. Flashlight or drop light
23. Standard screwdriver
24. Sharp knife, 6" blade
25. Carpenter's square optional
26. Set of wire crimpers optional

B. Materials

1. Items numbered 2, 3, 4, 5, & 7 provided by manufacturer, as listed for a two collector system

2. Coin vent

3. Copper elbows and tees

4. Two 3/4" copper slip couplings

5. Two 1" x 3/4" copper reducing couplings

6. 3/4" copper pipe, Type L or M

7. Two ventstacks, roofboot of 3" diameter

8. Pipe hangers 3/4" pipe, with rubber grommets

9. Steel wool

10. One can non-corrosive solder flux

11. Plumber sandpaper

12. One roll 95/5 solder

13. One roll pipe tape Teflon or one can pipe dope

14. Dishwashing liquid

15. Plumbers cloth

16. Steel brushes to clean I.O. fittings

17. Serrated kitchen knife

18. Inclinometer

19. Vise grip

20. Silicone rubber caulk

IX. GLOSSARY

ABSORBENT - the less volatile of the two working fluids in an absorption cooling device.

ABSORBER - the surface in a collector that absorbs solar radiation and converts it to heat energy; generally a matte black metallic surface is best.

ABSORPTION CHILLER - air conditioning device which uses heat at 190°F or higher to generate cooling; it may be powered by solar—heated water.

ABSORPTIVITY - the ratio of the energy absorbed by a surface to the energy absorbed by a black body at the same temperature.

ACTIVE SOLAR ENERGY SYSTEMS - in contrast to passive solar energy approaches, an active solar energy system utilizes outside energy to operate the system and to transfer the collected solar energy from the collector to storage and distribute it throughout the living unit. Active systems can provide space heating and cooling and domestic hot water.

AIRLOCK ENTRY - a vestibule enclosed with two airtight doors; it reduces heat loss by limiting the movement of heated air.

AIR-TYPE COLLECTOR - a collector that uses air for heat transfer.

ALTITUDE - the angular distance from the horizon to the sun.

AMBIENT TEMPERATURE - the natural temperature surrounding an object; it usually refers to outdoor temperature.

ATRIUM - a closed interior court to which other rooms open; it is often used for passive solar collection.

AUXILIARY ENERGY - auxiliary heat plus the energy required to operate pumps, blowers, or other devices.

AUXILIARY HEAT - the heat provided by a conventional heating system for periods of cloudiness or intense cold, when a solar heating system cannot provide enough heat.

AZIMUTH - the angular distance from true south to the point on the horizon directly below the sun.

BACKUP ENERGY SYSTEM - a backup energy system using conventional fuels should be provided for heating and domestic hot water. This system should be capable of providing all of the energy demand during any period when the solar energy system is not operating. Components and subsystems may be used as parts of both systems where the component or subsystem is a recognized, acceptable product in the conventional building industry.

BERM - see Earth berm.

BRITISH THERMAL UNIT (BTU) - a unit of heat; the quantity needed to raise the temperature of one pound of water one degree Fahrenheit.

BUILDING ENVELOPE - the elements (walls, roof, floors) of a building which enclose conditioned spaces.

CLERESTORY - a window located high in a wall near the eaves, used for light, heat gain, and ventilation.

COEFFICIENT OF HEAT TRANSMISSION - the rate of heat transmission measured per degree of temperature difference per hour, through a square foot of wall or other building surface. It is usually called the U-value.

COLLECTION - the process of trapping solar radiation and converting it to heat.

COLLECTOR - a device which collects solar radiation and converts it to heat.

COLLECTOR APERTURE - the glazed opening in a collector which admits solar radiation.

COLLECTOR EFFICIENCY - the ratio of the heat energy extracted from a collector to the solar energy striking it.

COLLECTOR TILT - the angle between the horizontal plane and the solar collector plane, designed to maximize the collection of solar radiation.

COMFORT ZONE - the range of temperature and humidity in which most people feel comfortable.

CONCENTRATING COLLECTOR - a collector with a lens or a reflector that concentrates the sun's rays on a relatively small absorber surface.

CONDUCTION - the flow of heat between a hotter material and a colder material that are in direct physical contact.

CONDUCTIVITY - the property of a material indicating the quantity of heat that will flow through one foot of a material for each degree of temperature difference.

CONVECTION, FORCED - commonly, the transfer of heat by the forced flow of air or water.

CONVECTION, NATURAL - the motion of a gas or liquid, caused by temperature or density difference, by which heat is transported.

COOLING POND - a large body of water that loses heat from its surface, largely by evaporation but also by convection and radiation.

COOLING TOWER - a device for cooling water by evaporation.

COVER PLATE - a layer of glass or transparent plastic placed above the absorber plate in a flat-plate collector to reduce heat losses.

DAMPER - a control which permits, prevents, or controls the passage of air through a duct.

DEGREE-DAY - a unit of measurement for outside temperature; it is the difference between a fixed temperature (usually 65°F (18°C)) and the average temperature for the day.

DESIGN HEATING LOAD - the total heat loss from a building under the most severe winter conditions likely to occur.

DESIGN OUTSIDE TEMPERATURE - the lowest outdoor temperature expected during a heating season.

DIFFUSE RADIATION - indirect scattered sunlight which casts no shadow.

DIRECT RADIATION - sunlight which casts shadows, also called beam radiation.

DIRECT SOLAR GAIN - a type of passive solar heating system in which solar radiation passes through the south-facing living space before being stored in the thermal mass for long-term heating.

DISTRIBUTION - the movement of collected heat to the living areas from collectors or storage.

DIURNAL TEMPERATURE RANGE - the variation in outdoor temperature between day and night.

DOUBLE-GLAZED - covered by two layers of glazing material (commonly, glass or plastic).

DOUBLE-WALLED HEAT EXCHANGER - a heat exchanger which separates the collector fluid from the potable water by two surfaces; it is required if the collector fluid is nonpotable.

DRAINBACK - a type of liquid heating system which is designed to drain into a tank when the pump is off.

DRAINDOWN - a type of liquid heating system which protects collectors from freezing by automatically draining when the pump is turned off.

EARTH BERM - a mound of dirt that abuts a building wall to stabilize interior temperature or to deflect the wind.

EMISSIVITY - the ratio of the energy radiated by a body to the energy radiated by a black body at the same temperature.

ENERGY AUDIT - an accounting of the forms of energy used during a designated period, such as monthly.

EUTECTIC SALTS - a mixture of two or more pure materials which melts at a constant temperature; a material which stores large amounts of latent heat.

EVAPORATIVE COOLING - a method of space conditioning which requires the addition of bodies of water or of moisture for cooling the living spaces.

FAN COIL - a unit consisting of a fan and a heat exchanger which transfers heat from liquid to air (or vice versa); usually located in a duct.

FLAT-PLATE COLLECTOR - a solar collection device in which sunlight is converted to heat on a flat surface; air or liquid flows through the collector to remove the heat.

FLYWHEEL EFFECT - the damping of interior temperature fluctuations by massive construction. (See Diurnal.)

FORCED-AIR HEAT - a conventional heating distribution system which uses a blower to circulate heated air.

GALVANIC CORROSION - the deterioration of tanks, pipes, or pumps, which occurs when a conducting liquid permits electrical contact between two different metals, causing the more active metal to corrode.

GLAUBER'S SALTS - a term for sodium sulfate decahydrate, which melts at 90°F; a component of eutectic salts.

GLAZING - a material which is translucent or transparent to solar radiation.

GREENHOUSE - in passive solar design, an attached glazed area from which heat is withdrawn to the living space during the day.

HEAT CAPACITY (SPECIFIC HEAT) - the quantity of heat required to raise the temperature of a given mass of a substance one degree F.

HEAT EXCHANGER - a device which transfers heat from one fluid to another.

HEAT GAIN - as applied to heating or cooling load, that amount of heat gained by a space from all sources (including people, lights, machines, sunshine, etc,).

HEAT PUMP - an electrically operated machine for heating and cooling; when heating, it transfers heat from one medium at a lower temperature (called the heat source) to a medium at a higher temperature (called the heat sink), thereby cooling the source (outside air) and warming the sink (the house); when cooling, the heat pump functions much like an air conditioner - taking unwanted heat from the heat source (a building) and dumping it to the heat sink (the outside).

HEAT SINK - a medium (water, earth, or air) capable of accepting heat.

HEAT SOURCE - a medium (water, earth, or air) from which heat is extracted.

HEAT TRANSFER - conduction, convection, or radiation, or a combination of these.

HEATING LOAD - the rate of heat flow required to maintain indoor comfort; measured in BTU per hour.

HEATING SEASON - the period from early fall to late spring during which heat is needed to keep a house comfortable.

HELIOSTAT - an instrument consisting of a mirror mounted on an axis moved by clockwork; the heliostat reflects sunbeams in one direction, usually to a central absorber located in a tower.

HYBRID SOLAR ENERGY SYSTEM - a hybrid system is one incorporating a major passive aspect, where at least one of the significant thermal energy flows is by natural means and at least one is by forced means.

HYDRONIC SYSTEM - a conventional heating system which circulates hot water, usually 160°F to 180°F, through baseboard finned pipes or radiators.

INDIRECT GAIN SOLAR - a type of passive solar heating system in which the storage is interposed between the collecting and the distributing surfaces (e.g., Trombe wall, water wall, or roof pond).

INFILTRATION - the uncontrolled movement of outdoor air into a building through leaks, cracks, windows, and doors.

INFRARED RADIATION - the invisible rays just beyond the red of the visible spectrum; their wavelengths are longer than those of the spectrum colors (.7 to 400 microns), and they have a penetrating heating effect.

INSOLATION - the amount of solar radiation (direct, diffuse, or reflected) striking a surface exposed to the sky; measured in BTU per square foot per hour (or in watts per square meter).

INSULATION - a material which increases resistance to heat flow.

ISOLATED SOLAR GAIN - a type of passive solar heating system in which heat is collected in one area to be used in another (e.g., greenhouse or attic collector).

KILOWATT - a measure of power or heat flow rate; it equals 3,413 BTU per hour.

KILOWATT HOUR (kWh) - the amount of energy equivalent to one kilowatt of power being used for one hour; 3,413 BTU.

LANGLEY - a measure of solar radiation; it equals one calorie per square centimeter, or 3.69 BTU per square foot.

LATENT HEAT - the change in heat content that occurs with a change in phase and without change in temperature; the heat stored in the material during melting or vaporization. Latent heat is recovered by freezing a liquid or by condensing a gas.

LIFE-CYCLE COST ANALYSIS - the accounting of capital, interest, and operating costs over the useful life of the solar system compared to those costs without the solar system.

LIQUID-TYPE COLLECTOR - a collector that uses a liquid as the heat transfer fluid.

MICROCLIMATE - the variation in regional climate at a specific site; caused by topography, vegetation, soil, water conditions, and construction.

MOVEABLE INSULATION - a device which reduces heat loss at night or during cloud periods and permits heat gain in sunny periods (e.g., Beadwall®, insulated draperies, automatic shutters); it may also be used to reduce heat gains in summer.

NOCTURNAL COOLING - a method of cooling through radiation of heat from warm surfaces to a clear night sky.

NONPOTABLE - water that is not suitable for drinking or cooking purposes.

NONRENEWABLE ENERGY SOURCE - a mineral energy source which is in limited supply, such as fossil (gas, oil, and coal) and nuclear fuels.

PASSIVE SOLAR ENERGY SYSTEMS AND CONCEPTS - passive solar heating applications generally involve energy collection through south-facing glazed areas; energy storage in the building mass or in special storage elements; energy distribution by natural means such as convection, conduction, or radiation with only minimal use of low-power fans or pumps; and a method controlling both high and low temperatures and energy flows. Passive cooling applications usually include methods of shading collector areas from exposure to the summer sun and provisions to induce ventilation to reduce internal temperatures and humidity.

PAYBACK - the time needed to recover the investment in a solar energy system.

PEAK LOAD - the maximum instantaneous demand for electrical power which determines the generating capacity required by a public utility.

PERCENT POSSIBLE SUNSHINE - the amount of radiation available compared to the amount which would be present if there were no cloud cover; usually measured on a monthly basis.

PHASE-CHANGE - see Latent heat.

PHOTOVOLTAIC CELL - a device without any moving parts that converts light directly into electricity by the excitement of electrons.

POTABLE - water that is suitable for drinking or cooking purposes, meeting the requirements of appropriate health officials.

PREHEAT - the use of solar energy to partially heat a substance, such as domestic potable water, prior to heating it to a higher desired temperature with auxiliary fuel.

PYRANOMETER - an instrument for measuring direct and diffuse solar radiation.

PYRHELIOMETER - an instrument that measures the intensity of the direct radiation from the sun; the diffuse component is not measured.

RADIATION - the process by which energy flows from one body to another when the bodies are separated by a space, even when a vacuum exists between them.

REFRIGERANT - fluid, such as Freon®, that is used in heating or cooling devices, such as heat pumps, air conditioners, or solar collectors.

RENEWABLE ENERGY SOURCE - solar energy and certain forms derived from it, such as wind, biomass, and hydro.

RERADIATION - the emission of previously absorbed radiation.

RETROFIT - to modify an existing building by adding a solar heating system or insulation.

ROCK BIN OR ROCK BED - a heat storage container filled with rocks or pebbles, used in air solar heating/cooling systems.

R-VALUE - see Thermal Resistance.

SEASONAL EFFICIENCY - the ratio of the solar energy collected and used to the solar energy striking the collector; measured over an entire heating season.

SELECTIVE SURFACE - a surface that is a good absorber of sunlight but a poor emitter of thermal radiation; used as a coating for absorbers to increase collector efficiency.

SENSIBLE HEAT - heat which, when gained or lost, results in a change in temperature.

SHADING COEFFICIENT - the ratio of the amount of sunlight transmitted through a window under specific conditions to the amount of sunlight transmitted through a single layer of common window glass under the same conditions.

SOLAR ACCESS OR SOLAR RIGHTS - the ability to receive direct sunlight which has passed over land located to the south; the protection of solar access is a legal issue.

SOLAR CELL - see Photovoltaic cell.

SOLAR COLLECTOR - a device which collects solar radiation and converts it to heat.

SOLAR CONSTANT - the average intensity of solar radiation reaching the earth outside the atmosphere; 429.2 BTU per square foot per hour (or 1,354 watts per square meter).

SOLAR FRACTION - the percentage of a building's seasonal heating requirement provided by a solar system.

SOLAR FURNACE - a solar concentrator used to produce very high temperatures; also a trade name for a modular air heating system, usually ground mounted, with rock storage.

SOLAR GAIN - the part of a building's heating load, or an additional cooling load, which is provided by solar radiation striking the building or passing into the building through windows.

SOLAR NOON - the time of day when the sun is due south; halfway between sunrise and sunset.

SOLAR RADIATION - energy radiated from the sun in the electromagnetic spectrum; visible light and infrared light are used by solar energy systems.

SOLAR THERMAL ELECTRIC POWER - the indirect conversion of solar energy into electricity by solar collectors, a heat engine, and electrical generators.

SOLARIUM - a living space enclosed by glazing; a greenhouse.

SPECIFIC HEAT CAPACITY - the quantity of heat needed to change the temperature of one pound of a material by one degree Fahrenheit (or one kilogram of a material by one degree Centigrade).

STACK EFFECT - the rising of heated air over a dark surface by natural convection to create a draft; used to provide summer ventilation in some passive houses.

STAGNATION - a high temperature condition obtained in a solar collector when the sun is shining and no fluid is flowing through the collector; temperatures range from 250°F to 400°F, depending on collector design. Any condition under which a collector is losing as much heat as it gains.

STORAGE - the device or medium that absorbs collected solar heat and stores it for later use.

STORAGE CAPACITY - the quantity of heat that can be contained in a storage device.

SUNSPACE - a living space enclosed by glazing; a solarium or greenhouse.

SUN-TEMPERING - sun-tempering is a method that involves a significant daytime solar gain and an effective distribution system but generally lacks a storage system.

THERM - a quantity of heat equal to 100,000 BTU; approximately 100 cubic feet of natural gas.

THERMAL LAG - in an indirect gain system, the time delay for heat to move from the outer collecting surface to the inner radiating surface.

THERMAL MASS - the heat capacity of a building material (brick, concrete, adobe, or water containers).

THERMAL RADIATION - see Infrared radiation.

THERMAL RESISTANCE (R-VALUE) - the tendency of a material to retard the flow of heat; the reciprocal of the coefficient of heat transmission.

THERMOSIPHONING - heat transfer through a fluid (such as air or liquid) by currents resulting from the natural fall of heavier, cool fluid and rise of lighter, warm fluid.

TILT ANGLE - see Collector tilt.

TRACKING - for a collector, a device which causes the panel to follow the sun.

TRANSFER MEDIUM - the substance that carries heat from the solar collector to storage or from storage to the living areas.

TRICKLE-TYPE COLLECTOR - a collector in which the heat transfer fluid flows in open channels on the absorber.

TROMBE WALL - masonry, typically 8 to 16 inches thick, blackened and exposed to the sun behind glazing; a passive solar heating system in which a masonry wall collects, stores, and distributes heat.

U-VALUE - see Coefficient of heat transmission.

VAPOR BARRIER - a waterproof liner used to prevent passage of moisture through the building structure. Vapor barriers in walls and ceilings should be located on the heated side of the building.

VENTILATION - a means of allowing moisture build-up (in winter) and hot air (in summer) to escape the house in a controlled and safe way.

WET-BULB TEMPERATURE - the lowest temperature attainable by evaporating water in the air; a measure of humidity.

ZONED HEATING - the control of the temperature in a room or a group of rooms independently of other rooms.

Prepared by the National Solar Heating and Cooling Information Center
Operated by the Franklin Research Center, for the
U.S. Department of Housing and Urban Development
in cooperation with the U.S. Department of Energy

Credits:

Federal Energy Administration, Buying Solar
(Washington, DC: Government Printing Office, June 1976, GPO
Stock No. 041-018-00120-4)

B. Anderson and M. Riordan, Solar Home Book
(Harrisville, NH: Cheshire Books, 1976)

U.S. Department of Housing & Urban Development, Cycle 5
Residential Solar Demonstrations, (Washington, DC: U.S.
Department of Housing & Urban Development, 3/79, RFGA #H-8800)

X. MULTI - MEDIA MATERIALS

1. Motion Pictures
2. Film Strips
3. Slide sets/cassettes
4. Overhead Masters
5. Additional sources

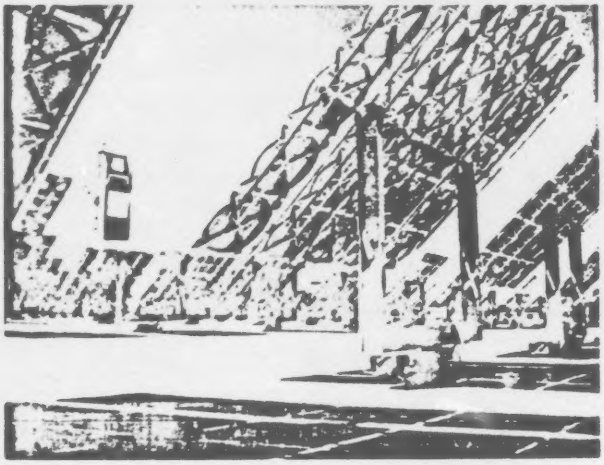
NOTE: Included will be a comprehensive listing of all currently (5/82) available A.V. materials. There has been no attempt to categorize these into distinctive groupings as per 1-4 above. Rather, the original context of their placement has been retained so that full advantage can be taken of:

1. Titles
2. Type of A.V. material
3. Source for communication purposes
4. Current costs
5. Description of contents of each A.V. unit in regard to outline of presentation with critiques often provided.

SOLAR POWER. **Handel Film Corp.,** 8730 Sunset Blvd., West Hollywood, CA 90069; 1980. (Prod.: Leo A. Handel.) 16mm. 20 min. Color. $325; $32.50 (rental).

JH-SH-GA-C ★ This film is probably best suited for showing in a community college or vocational school to students interested in career opportunities with solar power. It is not highly technical, but does cover the principles of the three conventional types of solar energy utilization—passive heating and cooling, active and photovoltaics. It includes some of the more advanced techniques, such as Trombe walls, large mirror arrays and solar panels on satellites with microwave transmission to earth. It has some good scenes of photovoltaic generation of power for a radar station, and agricultural and household use in remote areas. *Solar Power* could be used to introduce a course on solar energy or it could be shown to a general audience to promote an awareness of solar power and its possibilities. The photography and narration are of good professional quality.

—William A. Kemper



HOUSEHOLD ENERGY: THE SCIENCE OF CONSERVATION. **Educational Dimensions Group,** P.O. Box 126, Stamford, CT 06904; 1980. 2 color filmstrips, 60-80 frames ea.; 2 cassettes, 20 min. ea. $69. o.n. 1240AU. Accompanying teacher's guide and library kits.

EA-JH-SH-GA ★ The busy teacher will find these filmstrips an excellent introduction to energy and its conservation. Conservation is the theme, and practical information on what individuals can do to conserve household energy is given. The first filmstrip lays the foundation for the set by describing the nature of energy, energy conservation techniques, and solar energy. The second filmstrip describes electrical energy and how it may be produced. Direct and alternate current are examined and their differences noted. Heat is defined as a kind of energy, and energy conversion is introduced. The viewer is then led through an examination of household appliances, how they function and what one may do to ensure appliance efficiency. An excellent teacher's guide contains overviews, stated objectives, a script and other useful information. The set makes excellent supplementary classroom material on energy conservation and can be used effectively with groups or by individuals. *—Hans O. Andersen*

GENERATION ON THE WIND. **Churchill Films,** 662 N. Robertson Blvd., Los Angeles 90691; 1980. (Prod.: Windmill Movie Co.) 16mm. 26 min. Color. $430. Accompanying study guide.

JH Ac This pleasant, romanticized story details the cooperation efforts of citizens in a small island community who have pooled their time, energy, and material resources to fabricate, construct, and develop a windmill to generate power. The hope is that the windmill will greatly reduce the cost of electricity. Although the residents are skeptical about the outcome of the project, they are willing to be convinced. The value of the film lies not in the technical aspects of wind power but rather as a study of how people of diverse backgrounds are brought together by a desire to satisfy a community need. The film stresses that people of good will with little material resources but with much enthusiasm, ingenuity, and hard work can accomplish a project for the common good.

—Bruce L. Calder

GRASS ON THE ROOF. **Filmart Productions, Inc.,** 199 E. Annapolis St., St. Paul, MN 55118; 1980. (Prod.: Filmart Productions, Inc.; Dir.: Slavko Nowytski.) 16mm. 28 min. Color. $415; $40 (rental). 80-700096.

JH-SH-GA Ac Mortimer Pitts inherited his aunt's house upon her death, but her will stipulated he must spend an evening alone in it first. He learns it is an earth-sheltered structure and he is thus rather skeptical of the value of his inheritance, which is referred to unkindly by neighbors as "the mole hole." Like the classic mystery film in which an unsuspecting victim is lured to a haunted mansion, Mortimer hesitantly moves into his new habitat—during a frightful thunderstorm, of course—to find that it, too, is haunted, but by the benevolent spirit of his aunt. She leads her nephew on a marvelous journey through the world of earth-sheltered living, demonstrating that far from being "mole holes," such structures can be energy efficient, comfortable in summer and winter, economic, and esthetically pleasing. The viewer is introduced to a variety of structures—individual residences, condominiums, and even an earth-sheltered building on a university campus. At the end of the film, Mortimer—and this viewer—came away with an increased awareness of the value and acceptability of earth sheltered living. Cinematic techniques in the film are quite effective, but aside from the main characters, the acting is noticeably amateurish. The film should have broad appeal to general audiences and would be useful in junior and senior high school classes. *—Roger W. Mustalish*

SUN, WIND, AND WOOD. **Benchmark Films, Inc.,** 145 Scarborough Rd., Briarcliff Manor, NY 10510; 1980. (Prod.: National Film Board of Canada.) 16mm. 25 min. Color. $480; $50 (rental).

SH-GA-C Ac *Sun, Wind, and Wood* describes the efforts of a group called the New Alchemists to demonstrate the feasibility of using renewable resources for most of the energy

ENERGY NOW. **Adrian Vance Productions, Box 49210, Los Angeles 90049; 1980. (Prod.: Adrian Vance.) 6 color filmstrips, 88-126 frames ea.; 6 cassettes, 12-23 min. ea. $135. Accompanying teacher's guide.**

SH-GA-C ★ The distributor of this filmstrip set has given us an attractive presentation and has done his homework well. There is a good amount of *meaningful* quantification, but we are not deluged with quantities of huge, numbing numbers. The graphs are kept simple, and being in stark black and white, can be projected onto a chalkboard where the instructor could trace them. Some of the six filmstrips contain virtual field trips to interesting sites, and we are shown a facility by a person who works there and knows it intimately; it is his or her voice that provides the narration, in a spontaneous, informal mode. "Energy and Life" visits the San Diego Center for Appropriate Technology. The tour of all of the research gizmos on the roof is best, and the guide explains that many are really miniature prototypes for neighborhood or community application, an important point not widely understood. "Energy at Home" takes us through a standard home and many of the simple, easy and things we can do there to conserve energy. "The Nuclear Question" virtually ignores the usual pro and con arguments. Instead, it deals with unusual topics such as the way in which federal regulations allegedly motivate ambitious utility managers to favor nuclear energy—a huge capital expenditure coupled with technically skilled lower-echelon employees contributes to huge salaries at the top of the organization. While some of the content in the units may be too familiar, each filmstrip concludes with five discussion questions for review, speculation or student research. The accompanying teacher's guide also contains some useful teaching suggestions.—*Thomas Tanner*

BACKYARD ALTERNATIVE ENERGY. **Centron Films,** 1621 W. 9th St., Lawrence, KS 66044; 1980 (c. 1979). Prod.: A Kirby Brumfield Energy Production.) 16mm. 25 min. Color. $525; $52.50 (rental). o.n. A80514. 79-701218.

K-EP-EI-EA-JH; GA Ac The film is a brief collection of available alternate energy devices presently in use around the United States. Projects shown are water mills generating electrical energy, windmills on a five-story building, solar greenhouses, pedal power and storage of electricity for use in golf carts. Although this film is recommended for general audiences, it would be too juvenile for college groups. The greatest appeal for this film would be found in grades K through 9. The approach used is rather primitive but some of the projects shown do arouse interest. The photography is fair, sound level is good, but the ability to sustain the interest of an audience nearing the college level is doubtful.—*Robert C. Messina*

ENERGY FROM THE SUN, 2nd ed. **Encyclopaedia Britannica Educational Corp.,** 425 N. Michigan Ave., Chicago 60611; 1980. (Prod.: Encyclopaedia Britannica Educational Corp.; Dir.: Bert Van Bork.) 16mm. 18 min. Color. $305; $20 (rental). o.n. 3636.

EA-JH Ac This classroom film presents an introduction to the field of solar energy technology. It points out that the use of fossil fuels is simply the use of "yesterday's sun." The film shows current applications of solar technology in the form of domestic hot water systems (flat plate collectors) and a power generation system for farm irrigation pumps (focus collectors). The concept of a spectrum is introduced, and the varying effects of parts of the solar spectrum are mentioned. Research efforts in two areas are described: the search for an economical photovoltaic cell and efforts to obtain reliable electricity from wind generators. The measurement of solar cell efficiency is illustrated. Orbiting solar power stations are mentioned at the end as possible future sources of energy. There are two errors in the physics shown in the film. The "heat shimmer" produced by varying air density above hot surfaces due to uneven heating is described as "radiation" from the earth's surface. The variation in power output from wind generators is shown but the narration refers to frequency variation. An alert teacher might call attention to these errors in class discussions. The scope of the film is good, and the film quality is excellent.—*Gary P. Agin*

ENERGY: LESS IS MORE, 2nd ed. **Churchill Films,** 662 N. Robertson Blvd., Los Angeles 90069; 1980. (Dir.: Tom Smith, et, al.; from the *Energy* series.) 16mm. 21 min. Color. $375.

SH-GA-C ★ An excellent means of focusing the attention of an audience on energy prospects and alternatives, this film emphasizes transportation, economic inertia and doing more with less. Transportation is pointed out as the major energy-using sector. United States energy use in that sector continued to climb through 1978. While energy use also continued to rise in the residential and commercial sectors (which includes government), it declined in the industrial sector in response to rising prices. No comparisons between efficiency gains by different sectors or various industries using different energy sources are attempted. The point is made that most buildings are under-insulated and that modern construction practices involve energy-wasting inertia. Local, state and federal building codes can positively affect this situation. While the statement that education can have a large effect sells well in the academic community, the price mechanism is far more powerful. Europeans use less energy per unit of GNP because they pay two to three times as much for it. The accuracy of information in this film is good, as is the pace. The speakers are recognized experts.—*Raymond R. White*

ENERGY SEEKERS. **Centron Films,** 1621 W. 9th St., Box 687, Lawrence, KS 66044; 1980. (Prod.: Produced in cooperation with the American Iron and Steel Institute.) 16mm. 11 min. Color. $255; $25.50 (rental).

EA-JH-SH-GA-C ★ *Energy Seekers* starts by pointing out the importance of energy to us in our daily lives, how we depend on cheap energy and the need for additional energy. It mentions the various forms of energy, such as wind, nuclear fission, nuclear fusion, fossil fuels including oil, gas, oil from rocks, oil shale and crude oil, biomass, geothermal, hydrogen, methane from garbage, direct solar and photovoltaic cells. The conservation methods mentioned are lowering thermostats, using less fuel and maintaining speed limits on highways of 55 mph. The general conclusion is that there is not just one solution, but many possibilities. Not a great deal of technical information can be discussed in 11½ minutes, but that given is accurate and well balanced. The film, an excellent introduction to the topic, can be used in the classroom to lead students on to further study. The film is a bit dramatic, but should motivate further questions and interests, such as questions about cars that run on water (hydrogen) and oil derived from crops. This film could also be used for a general audience or run continuously at an energy fair.

—*C. Richard Cothern*

SOLAR: THE SOURCE. **Bergwall Productions, Inc.,** 839 Stewart Ave., Garden City, NY 11530; 1980. (Prod.: Bergwall Productions, Inc.; Dir.: Paul and Rita Henry.) 1 color filmstrip, 75 frames; 1 cassette, 16 min. $34. o.n. 190. Accompanying study guide.

JH-SH Ac *Solar: The Source* discusses passive collection, solar heating and cooling, concentrators, wind, biomass, photovoltaics, and science fiction. However, due to its short length, this filmstrip is little more than an illustrated list. In each instance, the narration is not quite clear. For example, an unlabeled fuzzy object is said to be a cutaway of a flat plate collector. The next frame shows a dark rectangular diagram labeled with various-sized arrows which sweep out arcs along the surface. The relationship between the two frames is not discussed. Later, a tiny, dark circle (which apparently represents a blown-up positive-negative junction) is described in terms of home-made jargon such as "charge potential." Too much of the filmstrip is centered on space fantasies. However, the photographs by Paul Henry are first-rate, often with dramatic angles or reflections. Captions would improve the educational effectiveness of some of the pictures, although it could be argued that they would spoil the aesthetic qualities. *Solar: The Source* may be useful as a general survey for high school students, but there are much better and more accurate filmstrips available on this subject. —*Robert Renthal*

TOWARD THE SUN. **Macmillan Films,** 34 MacQuesten Pkwy. S., Mount Vernon, NY 10550; 1981. (Prod.: Canadian Broadcasting Corp.) 16mm. 28 min. Color. $375; $35 (rental). Study guide available.

JH-SH-GA-C ★★ Without getting tied up in theory, *Toward the Sun* shows practical applications of solar energy utilization. The film successfully restricts its objectives to exploring in detail three widely different sites and methods: solar home heating in Toronto, solar batteries in a Nebraska irrigation system, and a prototype solar steam generator at the Los Alamos Laboratory. The film provides many useful comparative facts and estimates about the performance of the three sites. Clear diagrams and animation demonstrate the basic principles of heat transfer and *p-n* junctions. Carefully edited interviews with engineers are so well integrated into the narration that the extemporaneous remarks seem to be part of the script. Overall, this is among the best introductory films available on solar energy applications.

—*Robert Renthal*

WIND POWER. **Research Reports Center,** P.O. Box 50490, Palo Alto, CA 94303; 1980. (Prod.: Research Reports Center.) 16mm. 18 min. Color. $200.

JH-SH-GA-C ★ This almost poetic study of wind energy (WE) deals not with the technical, scientific aspects of the subject but rather with the current status of wind energy systems and how these systems fit into our energy picture. The film makes it clear that the wind has a definite role to play in our nation's energy future but cautions that the size and nature of that role remain to be determined. Research and development programs aimed at determining the reliability of wind turbines, the cost of wind-generated electricity, and the environmental impact of WE systems are examined. Wind turbine test sites in Rhode Island, North Carolina, and Hawaii are visited, and the reactions of private citizens, power company officials, and government representatives are presented. A cautious but optimistic picture emerges predicting that within ten years wind energy will begin to make a significant contribution in supplying our energy needs. The presentation is well balanced, entertaining, and suitable for audiences ranging from junior high school to adult.—*Harold B. Hart*

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■ Introduces transformation of fossilized plants and animals into oil, gas and coal ■ Examines current and emerging technologies for exploration ● production ● utilization ■ Details enhanced recovery of oil and gas ● new fuels from coal, oil shale and tar sands

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■ Presents overview of current and future uses of atomic energy from radioactivity to fission and fusion reactions ■ Details use of power reactors for research ● utility power ● transport power ■ Shows use of irradiation for food preservation and medical treatment ● use of radioisotopes in scientific research, medical diagnosis and manufacturing

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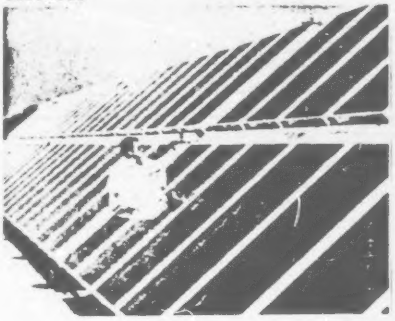


Slide Sets

Set A: Passive Solar Energy—General. An introduction to passive uses of solar energy including definitions and pictures of direct gain, thermal storage walls, attached greenhouses, natural convection, and roof pond systems.

Set B: Passive Solar Energy—Direct Gain. Includes eleven different Direct Gain applications in various climates.

Set C: Passive Solar Energy—Solar Geometry, Shading, and Movable Insulation. This set explores three vital considerations of passive solar design.

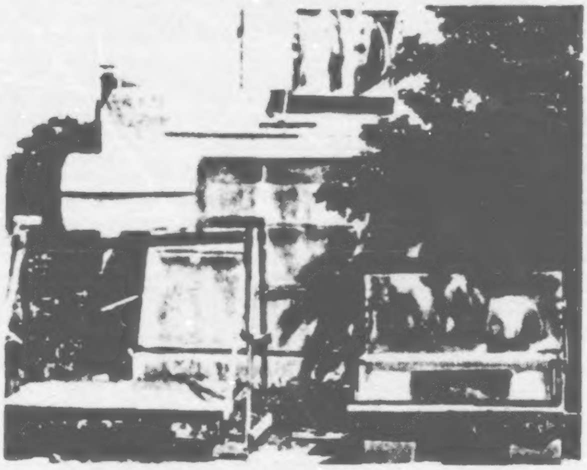
Set D: Passive Solar Energy—Thermal Storage Walls. Includes masonry Trombe walls, Drum walls, and Combination water and masonry walls.

Set E: Passive Solar Energy—Attached Greenhouses. Twelve different applications of both integral and retrofit greenhouses.

Set F: Passive Solar Energy—Convective Loops and Roof Ponds. Water and Air convective systems, roof ponds in California and New Mexico.

Dr. J. D. Balcomb, Solar Program Coordinator of the Los Alamos Scientific Laboratories, has written a lecture on solar energy to supplement the slide sets. The recorded lecture is available on cassette for $5.00 (no extra postage when ordered with a slide set).

Prepaid orders only, please include $12.00 per set ($10 for NMSEA members), plus $.75 per set for postage. **Complete set:** $60.00 for members plus $4.50 postage, non-members $72.00 plus $4.50 postage. American currency please. Foreign orders please add 10%. Allow 4-6 weeks for delivery.



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5403 ALTERNATE ENERGY $35.00
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5404 SOLAR ENERGY PROCESSES: IMPLEMENTATION $35.00
The concern of this filmstrip is the in-depth analysis of several existing research systems. Photographs of the various components and their actual relationship to the practical system along with a section on economic and environmental practicality bring home the actual utility of the Solar Energy System.

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Deals with the fundamental physical principles involved in the study of solar energy. Illustrations of the earth's spatial relationship to the sun as well as the fate of raditions incident upon the earth's surface, demonstrate the behavior of that portion of the electromagretic spectrum important to solar research.

5406 SOLAR ENERGY PROCESSES: THEORY, PART II $35.00
Outlines the physics behind heat transfer through examination of hardware involved in the measurement and collection of solar energy. Research instruments, flat plate collectors, semi-imaging units and solar imaging furnaces are examined.

5407 SOLAR ENERGY PROCESSES: SYSTEMS, PART I $35.00
Explores the diverse approaches to the collection of solar energy, accomplished through analysis of the hardware involved. Illustrations detail the working of modern flat plate, semi-imaging and true focusing collectors.

5408 SOLAR ENERGY PROCESSES: SYSTEMS, PART II $35.00
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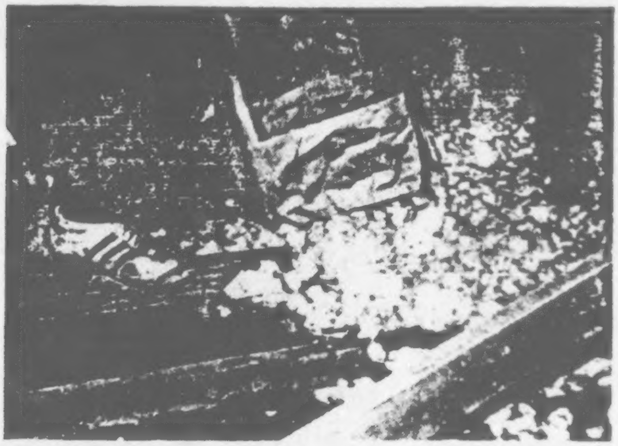

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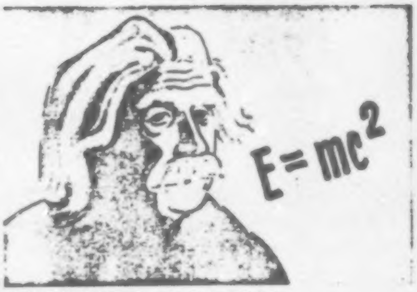
SOLAR ENERGY PROCESSES: THEORY, PART I

PRODUCED 1979

Solar Energy Processes: Theory, Part I deals with the fundamental physical principles involved in the study of solar energy. The structure of the sun and the reactions powering it are discussed. Illustrations of the earth's spatial relationship to the sun as well as the fate of radiations incident upon the earth's surface, demonstrate the behavior of that portion of the electromagnetic spectrum important to solar research.

Color-Sound Filmstrip: 47 frames Time: 14 minutes
Level: High School, College, Vo-Tech

Price: $30.00



SILVER AWARD-International Film & TV Festival of New York

SOLAR ENERGY PROCESSES: THEORY, PART II

PRODUCED 1979

This filmstrip outlines the physics behind heat transfer through examination of the hardware involved in the measurement and collection of solar energy. Research instruments, flat plate collectors, semi-imaging units and solar imaging furnaces are examined through the use of cut away diagrams and anotated illustrations.

Color-Sound Filmstrip: 40 frames Time: 14 minutes
Level: High School, College, Vo-Tech

Price: $30.00

Short Wave Radiations
Longer Wave Radiations

SILVER AWARD-International Film & TV Festival of New York

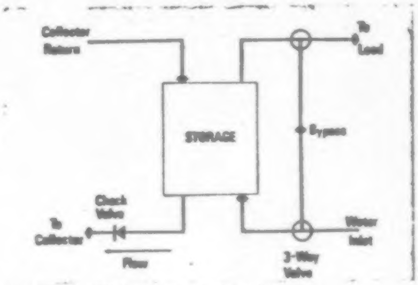
SOLAR ENERGY PROCESSES: SYSTEMS, PART I

PRODUCED 1979

This filmstrip explores the diverse approaches to the collection of solar energy. This is accomplished through analysis of the hardware involved in these processes. Illustrations carefully detail the working of modern flat plate, semi-imaging and true focusing collectors to prepare the student for practical experience with solar energy systems.

Color-Sound Filmstrip: 59 frames Time: 19 minutes
Level: High School, College, Vo-Tech

Price: $30.00



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SOLAR ENERGY PROCESSES: SYSTEMS, PART II

PRODUCED 1979

The time dependent nature of solar energy necessitates an understanding of the systemic approach to the study of this field. Systems theory is discussed with specific emphasis on the common elements of a solar energy system and their diagrammatic nomenclature. Application of this information is realized through a look at typical solar heating and cooling systems, water heating systems and future domestic applications.

Color-Sound Filmstrip: 59 frames Time: 19 minutes
Level: High School, College, Vo-Tech

Price: $30.00

PHOTOVOLTAIC SOLAR

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83.

from VOCATIONAL FILMSTRIP CO.

ALTERNATE ENERGY

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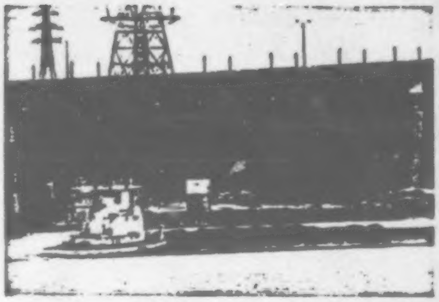
The demand on our planet's limited fossil fuel reserves will deplete our energy supply unless alternate energy sources are found and developed. This filmstrip outlines many modern approaches to the problem, since no single clear cut solution is available. Conventional energy sources are discussed in relationship to these new fields of research: solar heating, cooling and power; nuclear power; geothermal and ocean thermal gradient power as well as new stimulated light emission power techniques.

Color-Sound Filmstrip: 72 frames Time: 30 minutes
Level: High School, College, Vo-Tech

Price: $36.00



SOLAR ENERGY PROCESSES: IMPLEMENTATION

PRODUCED 1979

The concern of this filmstrip is the in-depth analysis of several existing research systems. Photographs of the various components and their actual relationship to the practical system along with a section on economic and environmental practicality bring home the actual utility of the Solar Energy System. Photographic analysis lets the student actually see the nature of solar research in the field today and its application in domestic and commercial use.

Color-Sound Filmstrip: 74 frames Time: 23 minutes
Level: High School, College, Vo-Tech

Price: $30.00

SILVER AWARD-International Film & TV Festival of New York

from — CAREER AIDS, INC.
8950 LURLINE AVE., DEPT. KB
CHATSWORTH, CAL. 91311

INTRODUCTION TO SOLAR ENERGY

Modern Considerations — A historical introduction to solar energy and passive systems, description of active systems requiring new equipment, comparison of three systems.

Components — The function of pipe collector loops, storage tanks, differential thermostats, pumps and blowers, solar collectors and absorber plates.

Solar's Near And Distant Future — A discussion of passive systems within the environment and techniques of the future as well as current experiments in thermal power and absorption refrigeration.

3 Color Filmstrips, 3 Cassettes, Reproducible Masters, Program Guide

PX1096 Introduction To Solar Energy $130.00

INSTALLING SOLAR SYSTEMS

Installing Solar Space Heating And DHW Systems — Components and construction materials are described: also what to look for, how and where to install, costs and return on costs, and retrofitting an existing house for space heating.

Collector Panels And Plumbing — How to resist corrosion and leakage of toxic fluids, insulate tanks and heat exchangers and pipes, waterproof exterior insulation. Also, how to install collector panels and piping.

Storage Media And Heat Exchangers — A comparison between steel lined and fiberglass tanks. Includes installation of the storage tank and solar DHW heat exchangers and designs.

Controllers And Wiring — A discussion of the controller's function of when to collect heat and when to shut down, its basic components, proper installation, and a check of the entire wiring system.

4 Color Filmstrips, 4 Cassettes, Reproducible Masters, Program Guide

PX1097 Installing Solar Systems $170.00

******** *Order the complete series and save!* ********

PX1098 Solar Energy (7 Programs) $259.00

SOLAR ENERGY PROCESSES: THEORY, PART I

Deals with the fundamental physical principles involved in the study of solar energy. The structure of the sun and the reactions powering it are discussed. Illustrations of the earth's spatial relationship to the sun as well as the fate or radiations incident upon the earth's surface, demonstrate the behavior of that portion of the electromagnetic spectrum important to the solar research.

Color-Sound Filmstrip (47 frames), Time: 16 minutes.

LX200 Solar Energy Processes: Theory, Part I $38.00

SOLAR ENERGY PROCESSES: THEORY PART II

This filmstrip outlines the physics behind heat transfer through examination of the hardware involved in the measurement and collection of solar energy. Research instruments, flat plate collectors, semi-imaging units and solar imaging furnaces are examined through the use of cut away diagrams and annotated illustrations.

Color-Sound Filmstrip (40 frames), Time: 14 minutes

LX201 Solar Energy Processes: Theory, Part II $38.00

ALTERNATE ENERGY

The demand on our planet's fuel reserves will delete our energy supply unless alternate energy sources are found and developed. This filmstrip outlines many modern approaches to the problem, since no single clear cut solution is available. Conventional energy sources are discussed in relationship to these new fields of research: solar heating, cooling and power; nuclear power; geothermal and ocean thermal gradient power as well as new stimulated light emission power techniques.

Color-Sound Filmstrip (72 frames), Time: 38 minutes

LX205 Alternate Energy....................... $38.00

SOLAR ENERGY PROCESSES: IMPLEMENTATION

The concern of this filmstrip is the in-depth analysis of several existing research systems. Photographic analysis lets the student actually see the nature of solar research in the field today and its application in domestic and commercial use.

Color-Sound Filmstrip (60 frames), Time: 18 minutes

LX204 Solar Energy Processes: Implementation .. $38.00

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SAVE $10 on 4-program group
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Each program $25.

55-181 Installing a Thermostat
Illustrates replacement of existing thermostat with energy-saving type; describes functions of major parts; details procedures for installation; outlines important tools

55-182 Installing Roll Insulation
Demonstrates techniques for installation; defines R-values, vapor barriers; outlines safety precautions

55-183 Insulating Pipes
Describes heat loss from hot air ducts, hot water pipes; identifies various insulation; illustrates installation techniques; discusses foam pipe wrap, duct tape, duct wrap, fiberglass pipe wrap

55-184 BTU's for Home Heating
Graphically explains British Thermal Unit, factors for determining required number of BTU's for a home; illustrates factors - doors, windows, landscape, room sizes

from — SINGER CAREER SYSTEMS
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ROCHESTER, N.Y. 14623

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SAVE $10 on 4-program group
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Describes the function and installation procedures for a storm window

•NEW **55-073 Weatherstripping a Door**
Explains the function and installation procedures for weatherstripping a door

•NEW **55-074 Locating and Repairing Roof Leaks**
Shows how to locate leaks, replace shingles and reseal flashing; stresses roof safety

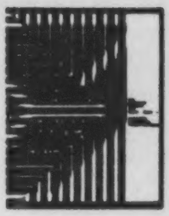
***New programs available Feb. 28, 1981.**

from PRENTICE HALL MEDIA SERV CODE ZU
150 WHITE PLAINS RD., TARRYTOWN, N.Y. 10591

Residential/Commercial

by Frank R. Dagostino

SOLAR



Solar Heating and Cooling Systems

Features the basic operation and processes of solar energy as they relate to residential and commercial solar heating and plumbing systems.

Solar Domestic Hot Water Systems and Installation

How solar energy systems provide domestic hot water. Procedures, coordination and precautions required for installation.

Heat Pumps

How heat pumps work and how they can be used for year-round air conditioning. Describes operation, components and use of supplemental heating units.

Complete Program: Solar

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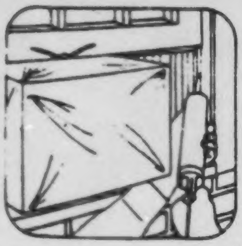
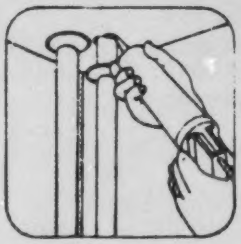
PRENTICE HALL MEDIA

6 Construction & Building Trades

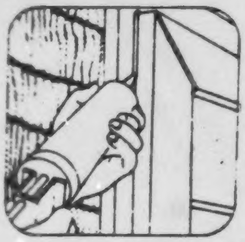
Weatherizing in Residential Construction

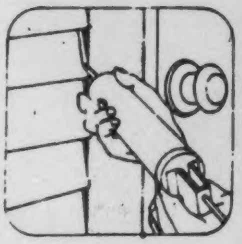
Making today's homes—both old and new—energy efficient has become a top priority. New techniques concentrating on heating and cooling systems have become fashionable, but the fundamentals of weatherizing a home have changed little over the years. This brand new audiovisual program demonstrates three basic procedures for producing an energy efficient home: caulking, weather stripping and proper ventilation. In six modules, the program describes the materials, tools and techniques in step by step detail.





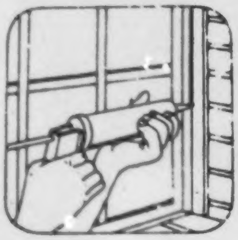
Introduction to Weatherizing This module discusses factors of weather and climate the home builder must understand in order to weatherize buildings effectively. These include atmospheric pressure, wind, moisture, humidity, ocean currents, as well as rain, snow and sun. The transfer of heat by conduction, convection and radiation is explained.

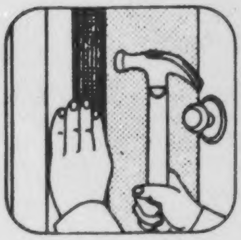




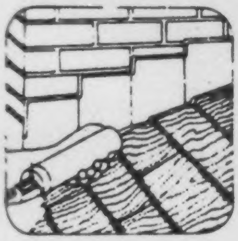
Caulking After explaining the use of caulking to close natural openings in joints, and the results of improper caulking, this module discusses caulking compounds, the materials on which to use them, and the advantages and disadvantages of each. Caulking compounds include oil based caulks, latex based, water-thinned, butyl rubber, silicone and acrylic latex.

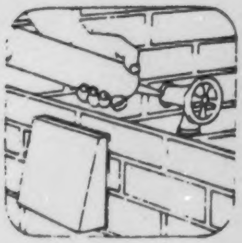
Where and How to Caulk Joints between siding and window or door frames, passages for plumbing or wire insulating strips, and around air conditioners are some areas requiring caulking. The equipment and tools are shown and set up, the surfaces of the caulking area cleaned, and caulking procedures demonstrated.





Weather Stripping Weather stripping to control heat, keep out moisture, dust and dirt, dampen vibrations and noise, and seal out light is discussed. The module then explains types of weather stripping and their application, advantages and disadvantages. Included are metal stripping with built-in spring tension, gasket type stripping, felt, plastic foam tape, rolled tubular vinyl, and many more.

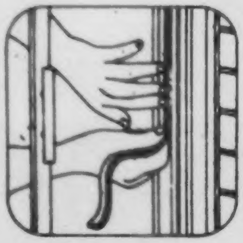


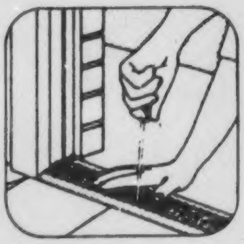


Where and How to Weather Strip This module shows the materials, tools and procedures for weather stripping doors with gasket type weather stripping, doors with built-in tension metal weather stripping, windows with gasket type weather stripping, windows with built-in tension metal weather stripping, and door bottom strips and thresholds.

Ventilation This module discusses the construction of homes with adequate circulation to reduce humidity and the frosting of roofs in winter, and to remove odors and hot air. It continues with demonstrations of attic ventilation, turbine roof ventilator, power roof ventilator, ventilation in living areas, and use of landscaping to create windbreaks and shade.

YZ991 Six Color Filmstrips, Six Cassettes, Program Guide, Reproducible Masters	**$239**





PRENTICE HALL MEDIA

Basic Measurement Math

NEW

Too often workers are called upon to use specialized math skills on the job before they are familiar with the basics. Training in basic measurement math skills intended to remedy this situation is offered in a new audiovisual program. In three modules, viewers will learn basic principles and some common applications of linear, perimeter, surface and volume measurements. Instructions are given in step by step detail to promote full understanding and retention. The confidence gained from this approach will enable trainees to undertake the more complicated math skills needed on the job.

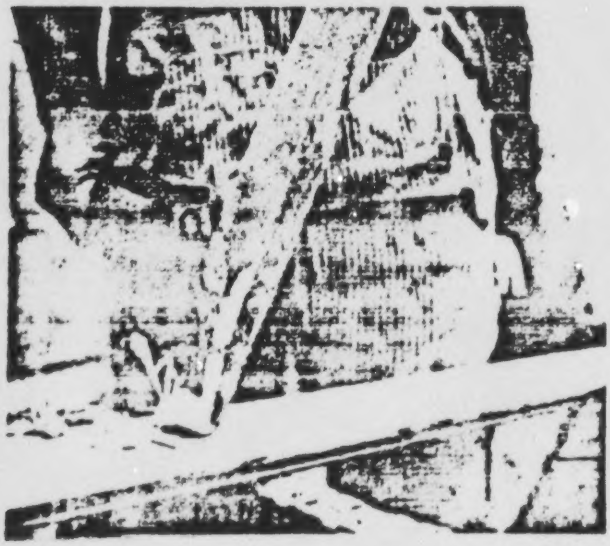
Linear Measurements demonstrates the practical skill of using the ruler in a variety of forms. The inch, foot, yard, and fractional parts of the inch, units most often used in vocational studies, are illustrated in working out common problems. The mechanics of placing the ruler (at zero), reading measurement, and the mathematics of linear unit conversion are discussed and graphically illustrated.

Perimeter and Surface Measurements begins by stressing the practical applications of perimeter and area measurement. The module considers such problems as how many feet of security fencing are required to surround a certain factory or how much carpeting is needed to cover a floor. The principles of perimeter, area and square units are each discussed.

Volume Measurements leads from everyday uses of volume and its relationship to capacity to the teaching of cubic units of measurements. Abstract concepts are clearly explained in concrete terms. Also provided are formulas to calculate rectangular and cylindrical capacities, and interconversion among the more important units of measurement including the liter.

YZ1039 Three Color Filmstrips, Three Cassettes, Program Guide, Reproducible Masters **$120**

Available January 1982



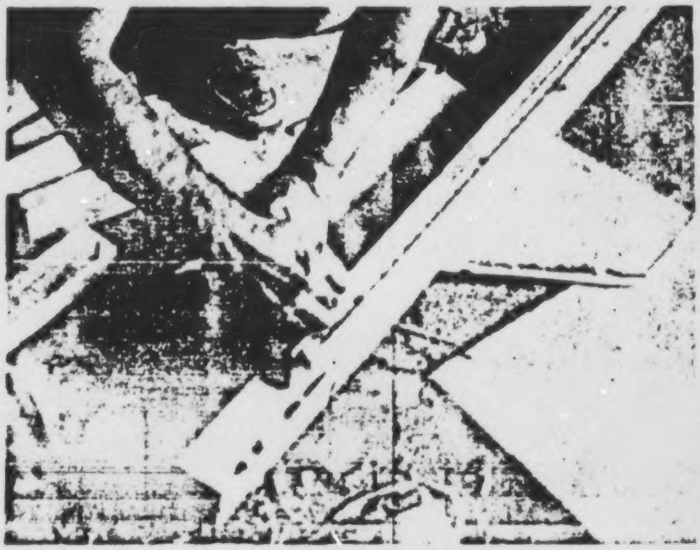
Safety in Residential Construction

Construction sites, with their multitude of tools, ladders and scaffolding, provide a number of hazards for careless, inattentive workers. Many accidents can be avoided by understanding and observing certain rules and by using safety equipment. This audiovisual program provides thorough training in correct safety procedures on residential construction sites. It details the proper use of hand tools and construction site materials, clothing and equipment, as well as safety precautions to follow when using ladders and scaffolding.

Hand Tools This module concentrates on skill and safety requirements for tools used by the residential carpenter. They include hammers, chisels, files and rasps, screwdrivers, wrenches and pliers, hand saws and the correct way to use the correctly chosen tool. There is a section explaining protective clothing and devices, and how to use these to protect against flying fragments, dirt or worn and misused tools. The carpenter is warned to be constantly aware of the actions of fellow workers. A safety test is given.

Ladders and Scaffolds The construction worker is introduced to different scaffolds found on the site, including sawhorses, double-pole wood scaffold, single pole wood scaffold, swinging scaffolds, standard tubular frame with brackets, metal sidewall bracket scaffold, post scaffold and work platforms, trestle jacks and guardrails. Scaffolding safety rules are demonstrated. Straight ladders, extension ladders, adjustable and trestle ladders are next shown, and safety rules demonstrated. A safety test completes the module.

YZ993 Two Color Filmstrips, Two Cassettes, Program Guide, Reproducible Masters **$80**



Solar Energy

The background knowledge and skills needed to install solar space heating and domestic hot water (DHW) systems in old and new buildings are taught in this brand new series. Close-up photography reinforces the concise, narrative instructions on the procedures and components involved in the systems.

With the rising costs of traditional heating sources, knowledge of solar heating techniques and installation is essential for everyone involved in designing, building and constructing new buildings or converting old ones. Technicians are needed to install and service systems. New techniques and equipment require specialized knowledge and proficiency in new areas. This program is designed to provide that knowledge and the skills needed in an expanding field.

The first three modules describe solar energy systems in general: The next four demonstrate installation procedures.

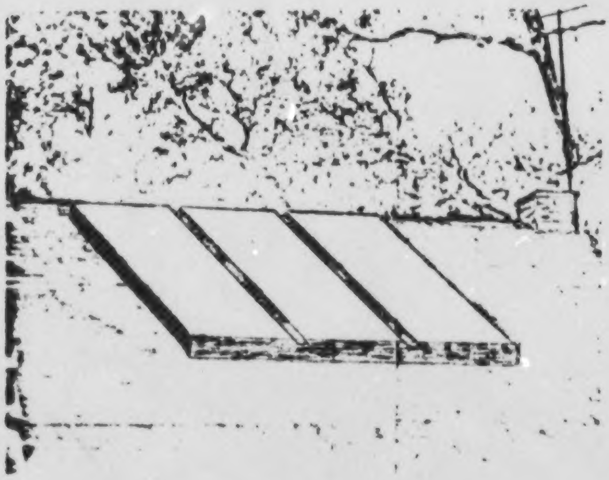
Introduction to Solar Energy

Modern Considerations After a historical introduction to solar energy and the use of passive systems relying on the orientation of a home to its environment, this module describes active systems requiring new equipment. Three systems and their economic advantages and disadvantages are considered.

Components This module discusses pipe collector loops, storage tanks, differential thermostats, pumps and blowers, solar collectors and absorber plates, their materials, how they function and their place in the system.

Solar's Near and Distant Future The first part of this module discusses passive systems making use of the environment or simple building techniques: reflective surfaces, insulated shutters, earth berms, water bags, rock bins, plain concrete walls and Trombe walls. This is followed by a description of solar energy techniques of the future and current experiments being carried out in high temperature solar thermal power plants and absorption refrigeration.

YZ1096 Three Color Filmstrips, Three Cassettes, Program Guide, Reproducible Masters **$130**



Installing Solar Systems

Installing Solar Space Heating and DHW Systems Requirements for installing DHW systems in existing houses are outlined. Components are described together with their construction materials, what to look for, how and where to install them, costs and return on costs. Requirements for retrofitting an existing house for space heating are similarly considered. Potential hazards and devices to counteract them are spelled out. Components and their installation are illustrated.

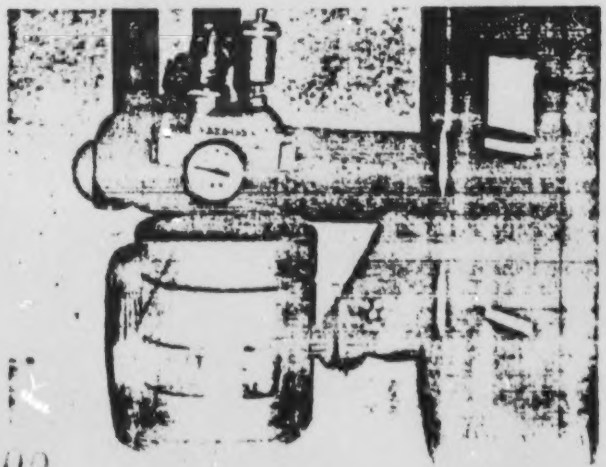
Collector Panels and Plumbing This module stresses the importance of proper materials and safety procedures to resist corrosion and leakage of toxic fluids, to insulate tanks and heat exchangers and pipes, and waterproof all openings of exterior insulation. Procedures for installing collector panels and piping are demonstrated.

Storage Media and Heat Exchangers The advantages and disadvantages of two types of storage tanks used in solar DHW or space heating system—steel lined with glass or concrete, and fiberglass tanks—are discussed. The function of the storage tank and its place in the system are outlined and installation procedures demonstrated. A discussion of solar DHW heat exchangers and designs follows, including tube-in-tube exchangers, parallel-tube heat exchangers, air-to-water heat exchangers, and finned tube heat exchangers.

Controllers and Wiring The controller's function in allowing the system to collect heat from the sun and to shut down all or part of the system when no solar energy is available is outlined. This is followed by a description of its basic components: the differential thermostat and temperature-reading sensors linked by electrical wiring. The pumps, blowers, valves and dampers that is must activate are illustrated. Proper installation of the controllers, including grounding, mounting and insulating, is demonstrated, and the entire wiring system checked.

YZ1097 Four Color Filmstrips, Four Cassettes, Program Guide, Reproducible Masters **$170**

Complete Series: **Solar Energy**
YZ1098 Seven Color Filmstrips, Seven Cassettes, Program Guide. Two Sets of Reproducible Masters **$259**



Additional Sources for Audio-Visual Materials

Modern Talking Picture Service
200 L Street NW, Washington, DC 20036; 16 Spear Street,
San Francisco, CA 94105 (Energy films)

Solar Lobby
1001 Connecticut Avenue, NW, Suite 510, Washington, DC
20036 (Comprehensive energy A-V listing, Solar Energy Education Bibliography, $3.75 + 15% shipping)

3-M Company
Visual Products Division, 3-M Center, St. Paul, MN 55101
(Energy films)

Total Environmental Action
Church Hill, Harrisville, NH 03450
(Solar slides)

U.S. Department of Energy Film Library
Box 62, Oak Ridge, TN 37830
(Energy films)

Zomeworks Corp.
Box 712, Albuquerque, NM 87103
(Solar slides)

Your local gas or electric utility

Your State Energy Office

XI.

RESOURCE ORGANIZATIONS AND AGENCIES

ASHRAE
345 East 47th Street, New York, NY 10017
(Publications catalog and price list)

Brace Research Institute
McDonald College of McGill University, Ste. Anne de Bellevue,
Quebec, Canada
(Do-it-yourself plans and leaflets)

Center for Renewable Resources
1001 Connecticut Avenue, NW, Suite 510, Washington, DC 20036
(Sources of funding and educational materials)

Mid-America Solar Energy Complex
Alpha Business Center, 8140 26th Avenue South, Minneapolis,
MN 55420

NASA
George C. Marshall Flight Center, AL 35812
(Solar publications list)

The National Center for Appropriate Technology
Box 3838, Butte, MT 59701

National Solar Heating and Cooling Information Center
Box 1607, Rockville, MD 20850 (800-523-2929)
(Pamphlets, bibliographies, fact sheets)

National Wildlife Federation
1412 16th Street, NW, Washington, DC 20036
(Pamphlets, magazines, catalogs)

New York Alliance to Save Energy
36 West 44th Street, Room 709, New York, NY 10036
(Energy Directory and Bibliography)

Northeast Solar Energy Center
    470 Atlantic Avenue, Boston, MA 02110
    (Brochures, newsletters, and curriculum materials)

Solar Energy Research Institute
    1536 Cole Blvd., Golden, CO 80401
    (Solar Energy Information Locator)

Solar Lobby
    1001 Connecticut Avenue, SW, Suite 510, Washington, DC 20036
    (Newsletters and brochures)

Solar Science Industries
    10762 Tucker Street, Beltsville, MD 20705
    (Catalog of solar energy books)

Southern Solar Energy Center
    61 Perimeter Park, Atlanta, GA 30341

Superintendent of Documents
    U.S. Government Printing Office, Washington, DC 20402
    (Solar Energy Bibliography SP-009)

Total Environmental Action
    Church Hill, Harrisville, NH 03450
    (Catalogs, books, plans, appropriate technology workshops)

U.S. Department of Energy
    Technical Information Center, Box 62, Oak Ridge, TN 37830
    (Books, brochures, posters, technical data)

VITA
    3706 Rhode Island Avenue, Mount Rainier, MD 20822
    (Simple survival technologies)

Western Solar Utilization Network
    Pioneer Park Building, Suite 800, 715 S.W. Morrison,
    Portland, OR 97205.

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Your State Energy Office

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- Solar and appropriate technology bookstore
- Tours of solar homes and buildings

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- How-to publications
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Santa Fe, New Mexico 87501

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- We charge for our services on a sliding scale, based on your ability to pay
- We work throughout the state and region
- We offer our services to individuals and groups of all kinds
- We are involved in research and development of low-cost solar applications

If you have ideas, questions or needs, call, write or stop in soon.

OFFICE HOURS: MON-FRI 9-5/SAT 12-4

XII. SOLAR SUPPLIERS

Catalog of Instructional Materials
(American Association for Vocational Instructional Materials, Engineering Center, Athens, GA 30502.)

Catalog of Instructional Materials
(Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112.)

ED-U-SOL Solar Kits
(Systems Using Nature, Ltd., Box 230, Ballston Lake, NY 12019.)

Guide to Home Energy
(Mother Earth News & Bookstore, Box 70, Hendersonville, NC 28791; solar and appropriate technology plans and component kits.)

Kwasnoski Solar Ed Kit
(Cooper Solar Dist. Co., 1627 Litchfield Turnpike, Woodbridge, CT 06525.)

People's Solar Source Book
(Solar Usage Now, 450 East Tiffin Street, Bascom, OH 44809; solar components catalog, $5.00.)

Solar Components
(Zomeworks, Box 712, Albuquerque, NM 87103.)

The Solar Components Book
(Solar Components, Division of Kalwall Corp., Manchester, NH 03105; solar components and hardware.)

Solar Shop Catalog
(Solar Unlimited, Inc., Box 337, Clay, KY 42404; catalog, $2.00.)

Solarette Solar Kit
(Solar Heat Corp., 108 Summer Street, Arlington, MA 02174.)

The Sotz News

(Sotz Corp., Columbia Station, OH 44028; wood-burning components and stove equipment.)

Edmund Scientific Co.
Edscorp Building, Barrington, NJ 08007
(science/solar materials)

Small Engine Distributors
1000 West 12th Street, Kansas City, MO 64101
(wholesale small engine components)

W. W. Grainger, Inc.
5959 Howard Street, Chicago, IL 60648
(wholesale energy system components)

XIII.

POTENTIAL USE
METRIC CONVERSIONS

Base Units	Common Prefixes
gram (g) = weight or mass	milli = 1/1000 or 0.001
meter (m) = length	centi = 1/100 or 0.01
square meter (m^2) = area	kilo = 1,000
liter (l) = volume	
calorie (c) = heat	
degree Celsius (°C) = temperature	
kilometer per hour (km/hr) = speed (velocity)	

Converting English Units to Metric Units

English units of measure have been used throughout the student activities. While we would have preferred to use metric units, there are two reasons why we did not:

It is difficult to obtain metric-sized lumber, accessories, and tools from today's construction industry.

It seemed cumbersome and confusing to report so many measurements in dual units.

The table below is intended to aid those who wish to use metric measurements with students.

Unit of Measure	English Unit	→ Multiply By ← Divide By	Metric Unit	Symbol
Length	inches	2.54	centimeters	cm
	feet	30.0	centimeters	cm
	feet	0.3	meters	m
	yards	0.91	meters	m
	miles	1.61	kilometers	km
Area	square inches	6.5	square centimeters	cm^2
	square feet	0.09	square meters	m^2
	square yards	0.8	square meters	m^2
Mass (Weight)	ounces	28	grams	g
	pounds	0.45	kilograms	kg
Volume	gallons	3.8	liters	l
	cubic feet	0.03	cubic meters	m^3
Temperature	degrees Fahrenheit	→5/9 (after subtracting 32) ←9/5 plus 32	degrees Celsius	°C
Heat	Btu	252	calories	c
Speed	miles per hour	1.61	kilometers per hour	km/hr

PART II

IMPLEMENTATION

NOTE: This part is so arranged that entire individual units may be pulled out for specific teaching needs - no one is totally dependant on the other - each is an entity unto itself.

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I. INTRODUCTION

PASSIVE SYSTEMS ORIENTATION

Passive solar affected climate control concerns itself with both heating and cooling depending on needs.

For Heating: The sun's energy enters any receptive object: house, atrium, automobile, etc. and heats it without the use of fans, pumps or other mechanical devices. The warmth moves by natural means: conduction, convection and radiation.

For Cooling: The night air, rain, and natural wind currents are used to absorb excessive warmth and discharge it to the outside (usually evening) air.

In passive solar heating, the sun's energy enters a building, is sometimes stored for later use, and heats the building without the use of fans, pumps, or other mechanical devices. The warmth moves by natural means—conduction, convection, and radiation.

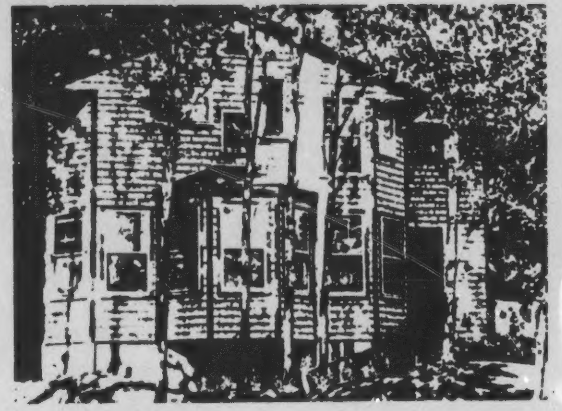
Passive designs are simple to understand, to build, and to operate. They go hand-in-hand with energy conscious building design and are usually less expensive than active systems which normally use pumps or fans. Their value increases as the value of the building increases. Existing buildings are often adaptable to passive designs.

On the other hand, since passive designs are an actual part of the building, new and improved building styles are possible.

The five passive examples shown here are representative of many other ways to use the sun's energy for heating—passively.

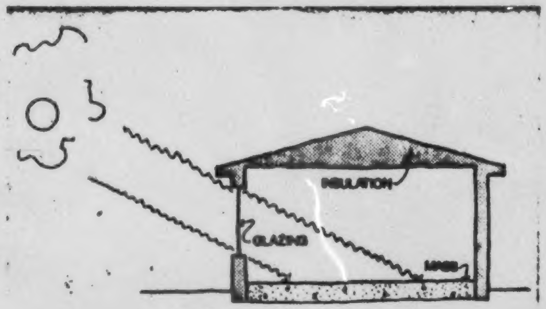
PASSIVE SOLAR HEATING

DIRECT GAIN



The most widely used form of solar heating is sunlight entering a building directly through windows. Most of the light which enters a building becomes heat. Large amounts of solar heat can be absorbed and stored by heavy materials in the building for later use. For example, concrete walls, slate floors, stone fireplaces, and even large containers of water absorb and store heat effectively.

Nearly everywhere in the continental United States, south-facing windows admit more heat energy than they lose. To effectively reduce heat loss through windows, at least two layers of glass are needed in cold climates. A third layer of glass, or alternatively, movable insulation (curtains or shutters) covering the glass at night, can reduce heat loss further.



THERMAL STORAGE WALL

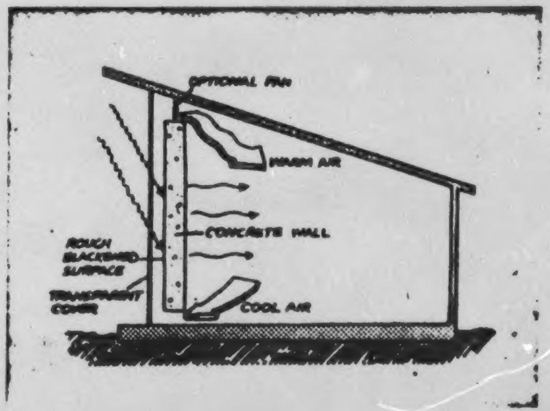
(INDIRECT GAIN)

When heavy material for storing solar heat is placed directly behind the windows in the path of sunlight, the temperature fluctuations in the building are reduced. The thermal storage wall is made of heavy materials such as concrete, stone, brick, adobe, earth or containers of water.

In the diagram, some of the heat is absorbed and conducted through the concrete wall. At night, the moderately warm wall radiates warmth to the building.

With the addition of vents at the bottom and top of the wall some of the heat enters the building immediately by natural convection.

ILLUSTRATION FROM THE SOLAR HOME BOOK

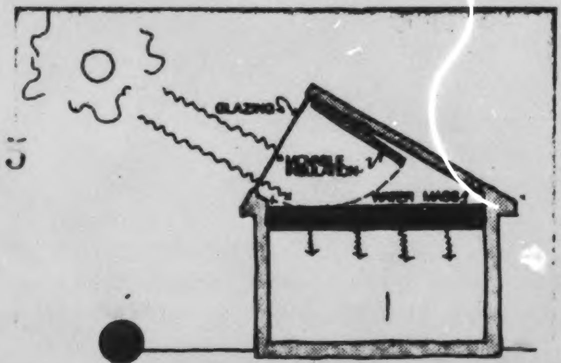


THERMAL STORAGE ROOF

(INDIRECT GAIN)

Heat storage materials normally used in thermal storage walls can instead be placed horizontally above the ceiling of a building. Most thermal storage roofs store solar heat in waterbed-like containers covering much or all of the ceiling. The solar heated water conducts its warmth through the ceiling and heats the building by radiation. When the sun is not shining, insulation covers the warm water to reduce heat loss. The insulating cover can also prevent overheating.

In mild and sunny climates such as the Southwest, this concept can provide 100% of all heating (and cooling) needs, completely eliminating fuel bills. For other parts of the country there is insufficient information available for making predictions of costs and energy savings using thermal storage roofs. See "Night Sky Radiation" on the reverse side of this brochure for the application of this concept to cooling.

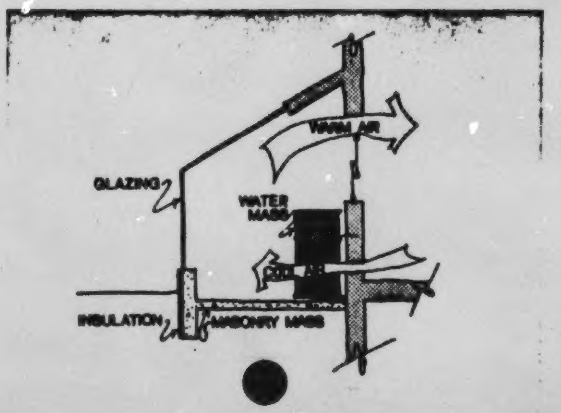


SUNSPACE

(ISOLATED GAIN)

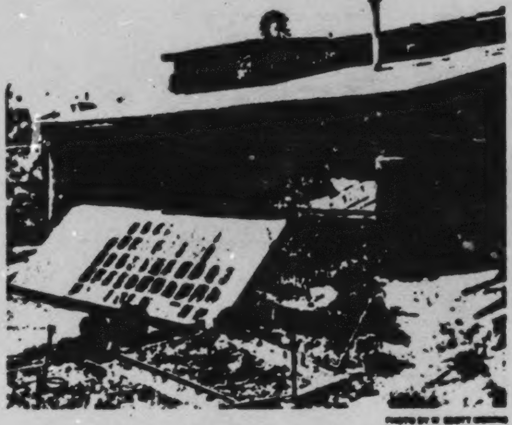
A well-designed greenhouse or other sunspace such as a porch or atrium can provide considerable solar heat to a building. It also reduces heat loss. The space has many uses, too. Thousands of people already use theirs for growing food and house plants and for pleasurable leisure activities.

Greenhouses can extend across the entire south side of a building. Heavy materials, such as masonry floors or containers of water, store excess solar heat. Multiple layers of glass or plastic, or alternatively, movable insulation (curtains or shutters) covering the glass at night, must be used (except in a very mild climate) to significantly reduce fuel bills.



CONVECTIVE LOOP

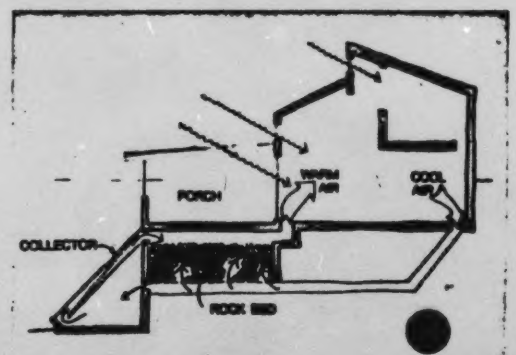
(ISOLATED GAIN)



When the sun heats air, the warmed air becomes buoyant. It rises, and cooler air moves in to replace it. This phenomenon is called convective air movement.

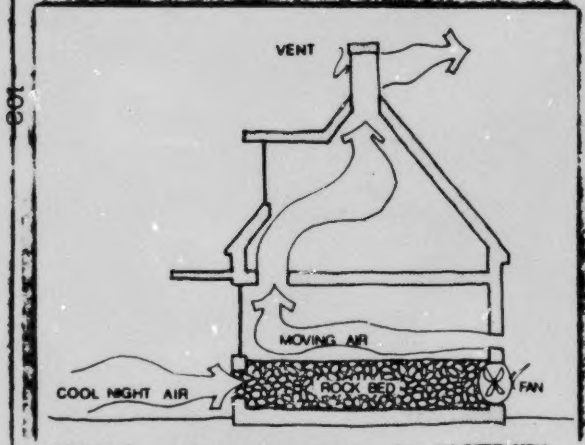
Most convective loop systems use solar collectors attached to or built into the walls of the building. As such, they replace some windows for gaining solar energy. The solar heated air in the collector enters the building, and cooler air from the building, in turn, enters the collector to be heated.

For collectors situated below the building, as in the diagram, a bed of rocks can store excess solar heat for later use.



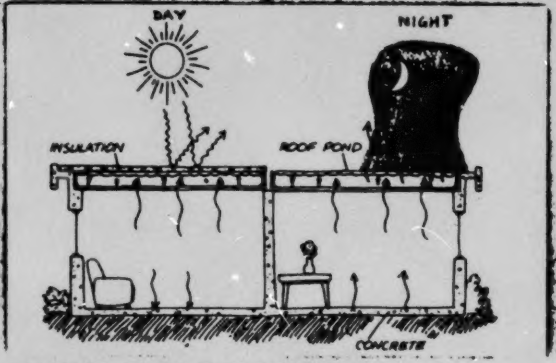
PASSIVE SOLAR COOLING

Through the ages, people have obtained relief from the heat of the sun by using simple cooling techniques that require no mechanical power. Mechanical air conditioning usually consumes non-renewable energy and is becoming increasingly expensive as energy prices rise. As a result, interest in non-mechanical, passive methods is increasing rapidly.



NIGHT AIR COOLING

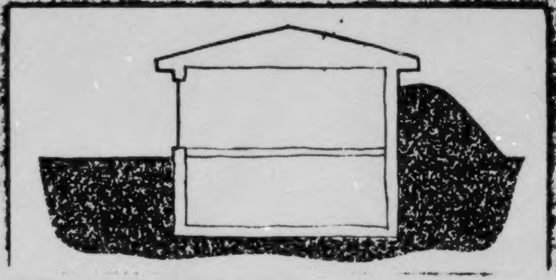
Cool night air can be brought into a building either by natural ventilation or with a fan. Cool night air can also be circulated through a bed of rocks beneath the house and then room air can be kept cool during the day by circulating it through the rockbed. If the floors, walls or ceilings of a building are constructed of heavy materials such as concrete, stone, brick, adobe, or earth, they can cool down at night and absorb the room's heat during the day.



NIGHT SKY RADIATION

Warm objects radiate heat to cooler objects. The earth, for example, radiates considerable heat to the night sky which, during clear weather, is quite cold.

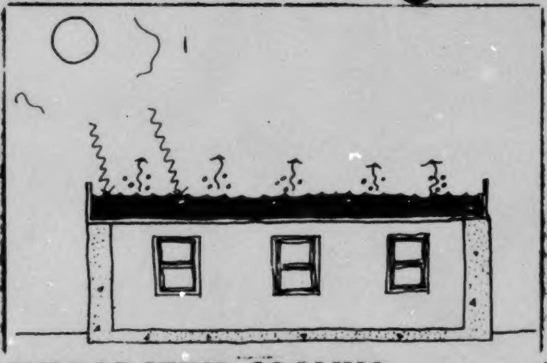
In hot climates where night skies are usually clear (such as the Southwest), some houses are cooled using this concept of night sky radiation. A heavy material such as water covers the roof. It absorbs heat from the house below and in turn radiates the heat to the cool, clear, night sky. During the day the heavy material is shaded from the sun.



GROUND COOLING

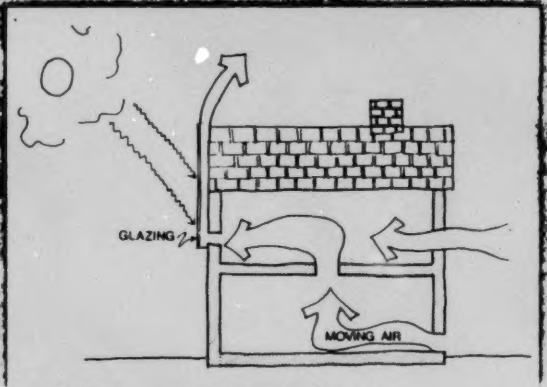
Since the ground is nearly always cooler than the air when cooling is required, the more a building is in contact with the ground, the cooler it will be.

Setting a building into the side of a hill or mounding earth as high as possible around the walls is the easiest way of obtaining more ground contact. Air drawn through cool pipes below ground is another way.



EVAPORATIVE COOLING

Hot, dry air can be cooled considerably when it is humidified. In dry climates, this is often achieved by the evaporation of water from pools, fountains, and sprays in and around buildings. When water evaporates, it lowers the air temperature and raises its humidity. Water covering the roof has a cooling effect as it evaporates.



NATURAL VENTILATION

The design of a building can greatly affect the ease with which outdoor air can flow through it. Properly positioned windows, for example, can dramatically improve cross ventilation. Tall spaces with openings at the floor and ceiling can induce natural ventilation, even in calm weather. Wind-driven rotating ventilators on the roof can assist natural air movement.

II. GENERAL BEHAVIORAL OBJECTIVES

This unit is the prefacing element for those specific behavioral objectives which follow and by their very nature are applicable directly to those specific areas of this Alternative Energy curriculum. This first, prefacing, unit of objectives, however, are so general as to be adaptable for the entirety of this Alternative Energy curriculum. These general objectives should be attainable by all involved students from grades 5 - 12

A. The student will be able to successfully demonstrate a: 1) theoretical and 2) practical understanding about solar radiation and its applied use via: 1) testing, 2) projects, and 3) discussion - - - i.e., of:

1. Electromagnetic radiation
2. Radiation wave length differences
    - a. Short - ultraviolet, 05%
    - b. Medium - visible light (Roy G. Biv), 46%
    - c. Long - infrared, 49%
3. The solar constant - which defines the amount of radiation or heat energy reaching the outside of the earth's atmosphere in:

a. B.T.U.s } per given area per hour
b. Calories }

4. The earth and its atmosphere as it pertains to solar energy reflection.

5. The interaction of captive solar energy that is useable, i.e. ---
   a. Absorbed
   b. Diffused
   c. Direct

6. Solar radiation travel time via length/depth of earth's atmosphere, i.e. ---
   a. Sunrise
   b. Noon high
   c. Sunset

7. The variance of atmosphere length in relation to earth's: 1) tilt, 2) rotation and with 3) respect to time of month and day.

8. Solar intensity on a (any) surface, i.e., ---
   a. Determination of efficiency
   b. Altitude of angle of sun
   c. Angle of incidence of sun

d. Reflection (specular and diffuse)

e. Transmission (transparent and translucent)

f. Absorption

9. Heat breakdown (characteristics of heat transfer)

a. Molecular conduction

b. Molecular convection

c. Radiation

1. Surface temperature

2. Surface emissivity

3. Surface absorption/transmission

4. Greenhouse effect

10. Heat storage/elimination

a. Material storage capacity

1. Solids

2. Gases

3. Liquids

b. Material conductivity

1. Solids

2. Gases

3. Liquids

B. The student will be able to correctly demonstrate a mastery of all currently functional solar induced climate/control systems via: 1) verbal discussion, 2) depiction, 3) construction, and 4) testing of:

1. Passive systems
    a. Direct gain
        1. Masonry walls and floors
        2. Water walls and floors
        3. Phase change walls and floors
    b. Indirect gain
        1. Trombe walls
        2. Roof ponds
    c. Isolated gain - - - (convective loop)
        1. Envelope method
        2. Removed sunspace
        3. External wall mounted collectors
2. Indicate advantages and disadvantages of passive systems - - -
3. Active systems - - - domestic hot water
    a. Direct - open, drain-down and drain back
    b. Indirect - closed loop/heat exchange method
    c. Batch hot H_2O heaters

4. Indicate advantages and disadvantages of active D. H.W. systems - - -

5. Hybrid systems

    a. Double envelope - southern exposure
    b. Isolated gain storage and retrieval
    c. Indirect gain storage and retrieval
    d. Direct gain storage and retrieval

6. Indicate advantages and disadvantages of hybrid systems

C. The student will be able to correctly: 1) identify, 2) design, 3) implement, and 4) supplement those elements of "Rules of Thumb"/patterns which are successful in establishing functional climate control systems, i.e.,

1. Design factors which give building/systems their overall shapes and crystallize site positions in respect to: sun, wind, trees, and terrain, i.e.,

    a. Building/system location
    b. Building/system shape and orientation
    c. North side
    d. Location of internal spaces
    e. Protected entrances/access
    f. Fenestration location

2. Utilize patterns providing criteria for proper selection of any passive system and give specifics for the design thereof, i.e.,

Appropriate materials availability

- a. Direct
  - 1. Solar windows
  - 2. Clerestories and skylights
  - 3. Masonry storage medium
  - 4. Interior H_2O walls
- b. Thermal storage wall systems
  - 1. Sizing the wall (s)
  - 2. Wall details
- c. Greenhouse/sunspace system (s)
  - 1. Sizing
  - 2. Orientation
  - 3. Connection to space for use
  - 4. Details
  - 5. Combining systems
  - 6. Cloudy day storage
- d. Roof pond system (s)
  - 1. Sizing
  - 2. Details

        e. Combining systems

    3. Utilize those supplementary means which will insure and enhance the fullest functional implementation of passive systems, i.e.,
        a. Movable insulation
        b. Reflectors
        c. Shading devices
        d. External/non-movable insulation (s)
        e. Summer/hot times cooling

D. The student will be able to correctly and properly identify and apply those information/data materials which will best serve to resolve the 1) understanding, 2) design of, and 3) the implementation of any alternative/solar energy systems (s), i.e.,

    1. Materials and energy use tables
    2. Solar radiation charts
    3. Surface absorption treatment charts
    4. Concrete mass systems performance charts
    5. Temperature fluctuation charts (in, out, seasons, latitude)
    6. Comparison systems charts

7. Comparison of masonry materials table

8. Climate annual percentage of solar heating table

9. Effect of wall thickness - space air temperature fluctuation table

10. Thermal storage materials charts (concrete, H_2O, phase change)

11. Climatic condition tables

12. Materials thickness tables

13. Clear day average temperature tables

14. Conduction losses through materials tables

15. Insulation efficiency tables:

    a. Permanent

    b. Movable

    c. Natural (seasonal)

16. Reflector/collector percentage of efficiency charts

17. Solar tilt angle reflector tables

18. Specular solar reflectance tables

III. CONSERVATION

I. Introduction

The normal use of energy as we have used it until the last 7 years or so must be altered if this nation is to survive its energy crises. With shortages and escalating prices everywhere, alternatives must be found! The most immediate and far reaching alternative providing the greatest benefits for our system without drastic changes or excessive funding is conservation. This has already been applied in varying forms by many for varied purposes. The end results are ever more astounding. Combined with super insulation this can cut a three bedroom house's heating bill for the entire heating season for our U.S. northernmost climate from 3 to 5 thousand dollars down to 50 dollars - - - from Oct. 1 to May 1. This has been verified by the Canadian Univ. of Saskatchawan studies[1] as well as of the Univ. of Illinois, Institute of Technology and several thousand houses built to appropriate new technology standards by willing energy conscious builders.

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[1] a) "Low Energy Passive Solar Housing" - S7N OWO
May, 1980, University of Saskatchewan, Saskatoom, Canada
b) "The Illinois Lo-Cal House" #C-2-3
c) "Technical Note # 14: Details and Engineering Analysis of the Illinois Lo-Cal House" - 1977, University of Illinois, Champaigne, Ill.

With this in mind then the most logical first step is weatherization of dwellings, public buildings, schools, churches/temples, arenas, industrial complexes, stores, automobiles, planes, ships, boats, recreational "in the wild" uses, etc. This will provide immediate benefits in comfort and cost effectiveness.

The second step is the application of super insulation. This can be gradual as funding dictates or totally when major referbishing must be done such as new siding, shingles, roofing, etc.

The final step is that of introducing retrofitted solar/alternative energy devices that will provide climate control relegating petroleum, gas, electricity, etc., to a purely back-up role.

II. Implementation

The solution to conservation as an alternative to wasteful energy use depends on several factors, if it is to be successful: 1) the desire and determination to effect change, 2) the reality of the necessity for this change, 3) the realization that fuel costs, oil, electricity, and gas are making us paupers if used as before, and 4) how and where this kind of implementation must begin. - - -

1. Weatherization is the first step in the functional conservation of not only our currently existing energy, but also of any and all types of future energy on the horizon and those not conceptually devised as yet. Other succeeding steps are:
2. Windor (window & door accepted Arch term) use - proper types
3. Caulking, weatherstripping, proper application
4. Moisture, vapor barrier, ventilation, proper use
5. Climate control equipment maintenance & proper use
6. H_2O conservation, control, proper use
7. H_2O heating, proper use
8. Home management tips, applied use

It should be noted that permission has been granted to utilize the following Conn. State energy outreach materials as the substance of this implementation unit. Also, insulation as such is covered in its own unit.

CONSERVATION

AGRICULTURAL ENGINEERING

College of Agriculture and Natural Resources The University of Connecticut, Storrs, Ct. 06268

Storrs, Conn.
06268

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

July 1978

CRH-2
(Revised)

CHECK LIST FOR HOUSEHOLD ENERGY CONSERVATION - WINTER

John W. Bartok, Jr., Extension Agricultural Engineer

With the existing shortages of fuel oil, Propane gas and natural gas, measures need to be taken to reduce their consumption. This check list has been written to help the homeowner or renter determine ways in which he can reduce energy consumption in and about the home.

Savings of as much as 40 to 50 percent may be realized if all of the items listed below are reviewed and put into practice. In addition, limiting the use of kitchen appliances, personal grooming aids and power tools will add to this savings.

- - - - - - - -

HOME INSULATION

___ 1. Storm Windows - An average size (30 x 52) inches single-glazed window looses the equivalent of 27 gallons of oil during a heating season. Adding a storm window will reduce this loss to about 11 gallons, a savings of 16 gallons per window. Do-it-yourself plastic storm windows can be purchased for less than $0.25 per window.

___ 2. Storm Doors - Adding wood or aluminum storm doors reduces air leakage and moisture loss.

___ 3. Ceiling Insulation - Application of insulation having an R-Value* of 13 to 30 to the attic ceiling may save up to 15% in the heating bill. Blanket, batt or loose fill insulations may be used. A vapor barrier should be placed on the heated room side of the insulation. Where insulation is being added to existing insulation, the paper or foil covering should be removed.

___ 4. Wall Insulation - Walls should contain insulation having an R-Value* of 11 to 14. This can be applied as batt insulation when remodeling or as blown or foamed in place insulation applied through the outside wall.

___ 5. Floor Insulation - Three inches of batt insulation should be placed in the floor over crawl spaces and unheated basements, A vapor barrier should be located on the warm side of the insulation.

*R-Value is a measure of resistance of heat flow from a warm to a cold surface. The larger the R-Value the better the insulation.

COOPERATIVE EXTENSION SERVICE
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THE UNIVERSITY OF CONNECTICUT, STORRS

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___ 6. Outside Doors - A great deal of heat escapes whenever outside doors are open, so always close doors as quickly as possible.

___ 7. Caulking - Cracks around window and door frames should be caulked to reduce air and moisture leakage. About 100 cubic feet of cold air enters through a 1 square inch hole each hour.

___ 8. Weather Stripping - All windows and doors should be weather-stripped. It costs about $2.50 a winter to heat the cold air that leaks in through a poorly fitted window. Proper weather-stripping will reduce this to $0.75.

___ 9. Insulating Drapes - Lined drapes with insulating cloth helps to reduce radiation loss to the outside. Keep drapes closed except when sunlight shines in. This traps cool air at the windows.

___ 10. Vacant Rooms - Keep doors to vacant rooms closed and reduce heat by lowering thermostat setting or partially closing the radiator valve or duct damper.

___ 11. Ventilating Fans - Kitchen and bathroom exhaust fans remove heat and moisture. Restrict their use during the cold season.

___ 12. Attic Vents - Adequate-sized ridge and eave vents remove moisture and helps keep insulation dry. Dry insulation reduces heat loss.

___ 13. Heated Garages - Lower temperature or shut off heat to conserve energy.

___ 14. Garage Doors - Keep doors of attached garage closed except when in use. This keeps the garage and the garage-house wall warmer.

___ 15. Mobile Home Foundation - Attach skirts around the foundation to reduce air movement.

HEATING

___ 16. Thermostat Setting - Lowering the thermostat setting can save a significant amount of fuel. For example, if your average yearly use is 1500 gallons of oil, lowering the thermostat from 73° to 68° will save about 200 gallons.

___ 17. Night Thermostat Set-back - Turning the thermostat back at night will save money and make sleeping more comfortable. Savings of about 9% can be realized when the temperature is reduced from 70° to 60° in a poorly insulated house. The saving is less in a well insulated house. Day-Night clock type thermostat controls eliminate the need for manual adjustment.

___ 18. Vacation Set-back - Lower thermostats to 50° when leaving for a vacation or the weekend.

___ 19. Increase Humidity - Install a humidifier to increase relative humidity. A temperature of 68° and relative humidity of 30% give the same sensation of comfort as a temperature of 71½° and relative humidity of 10%.

___ 20. Thermostat Accuracy - Many home thermostats read incorrectly. Place an accurate thermometer next to the thermostat and mark the setting on the thermostat.

___ 21. Furnace Efficiency - Large savings in fuel can be obtained by having the furnace adjusted properly. A mere 1/8 inch soot deposit may increase fuel consumption by 10%. Your heating service man has the tools and instruments to do the job properly.

___ 22. Radiators - Dust and dirt restrict the flow of heat from a radiator. Remove radiator enclosure and brush or vacuum the radiator once a month during the heating season. Check to see if dampers or flaps on baseboard units are open.

___ 23. Heating Pipe Insulation - Pipes or ducts that run through unheated basements or unused areas should be insulated. In two years the insulation will be paid for from the fuel saved.

___ 24. Air Filters - Dirty or clogged air filters increase both blower and furnace operating time. It pays to replace these at least every two months during the heating season.

___ 25. Radiator Shield - Place aluminum foil or galvanized sheet metal behind cast iron radiators to reflect heat back into the room.

___ 26. Radiator Valves - Air that collects in steam and hot water radiators is discharged through the air valve. Leaky or defective valves should be repaired or replaced.

___ 27. Thermostat Location - A thermostat located near a door or at the foot of a stairway may cause the furnace to operated when there is no need for more heat in the house. Have the service man move it to an inside wall.

___ 28. Heating System Balance - Adjust valves or dampers in the heat distribution system to get the desired temperature in each room. When one room is too hot and another is too cold, the system is out of balance and uses more fuel than necessary.

___ 29. Register and Radiator Obstructions - Restricting the flow of heat by placing furniture in front of radiators or registers causes the heating system to operate longer periods of time to warm a room.

___ 30. Fireplace Damper - Close fireplace damper when not in use. The air in an average size room can be displaced in about 15 minutes on a cold night if the damper is left open.

___ 31. **Fireplace Use** - Only about 10% of the heat value of wood is transmitted into the room in a conventional fireplace. Fireplaces should not be used when the weather is very cold and windy. A better use of the wood would be to install a "Franklin" type stove in the fireplace opening with the flue connected to the fireplace flue.

LIGHTING/APPLIANCES

___ 32. **Electricity Use** - Turn off appliances and lights when not needed. Eliminating the use of just 100 watts in lights or appliances will save 866 kilowatt hours per year resulting in a saving of about $43 in your electric bill.

___ 33. **Bulb Size** - Use the correct size bulb for the job. Illumination can be reduced in many areas of the home. Light bulbs and fixtures should also be kept clean. Fluorescent lights give more than 3 times as much light as incandescent bulbs for each kilowatt used. Use direct lighting i.e., table or floor lamps for reading instead of ceiling lights.

___ 34. **Appliance Purchase** - Check power consumption of appliances you are planning to purchase. Buy the one that gives the best performance with the least energy consumption.

___ 35. **Appliance Use** - Small heating appliances such as electric fry pans, toaster ovens and percolators are more efficient than using the range burner and pots or the oven. An oven uses twice as much energy as an electric fry pan.

___ 36. **Refrigerator Purchase** - When buying a new refrigerator, consider the fact that a frostless one uses almost twice as much electricity to operate as a conventional defrost type. Chest type freezers use less energy than front opening types.

___ 37. **Refrigerator - Freezer Use** - Remove all the foods necessary for a meal at one time. Store foods in covered containers to reduce frost accumulation. Defrost when the frost is 1/4" thick. Operate at the proper temperature - 0°F for freezer, 34° - 40°F for the refrigerator.

___ 38. **Cooking Units** - Turn ovens and range surface units off when not needed. A 2000 watt unit left burning for 1/2 hour will use about 5¢ of electricity.

___ 39. **Oven Use** - Keep oven doors closed until food is cooked. The temperature in the oven drops 25° to 50° each time the door is open. Broil foods whenever possible. Cooking time is shortened considerably.

___ 40. **Range Top Use** - Cook food at the correct temperature. Use high heat to bring food to the desired temperature, then lower the heat. Heat is wasted by using the high heat setting. Select pots with flat bottoms and tight fitting covers.

___ 41. Food Preparation - Where long cooking time is required, prepare double or triple recipes. Store or freeze the unused portion. Pressure cookers save energy by reducing cooking time.

___ 42. Dishwasher Use - Dishwashers use the same amount of water whether full or partially empty. Collect a full load of dishes before running the dishwasher. Let dishes air dry by turning off the control knob of the dishwasher after the final rinse and opening the door.

___ 43. Laundry Use - Wash clothes with cold or warm water where possible. Wait until you have a full load to operate the washer or dryer. Use outside clothes line during good weather. Purchase no-ironing type clothes. Do all the ironing at one time to reduce the heat loss in warm-up and cool-down.

___ 44. Water Faucets - Eliminate all water leaks. A faucet dripping at 60 drops per minute will waste 113 gallons per month. If this is hot water at 150°F it will cost $1.00 per month to heat it with electricity or 50 cents with oil.

___ 45. Water Heater - Heat water to the lowest temperature needed. Most water heaters should be set for 130-140°F. Use hot water only when it is needed.

___ 46. Pipe Insulation - Insulate hot water pipes and tanks to reduce heat loss. The cost of insulation will be paid for in less than a year.

___ 47. Water Tank - In non-municipal water systems, drain tanks when needed to avoid a "waterlogged" condition. Install pre-charged water tanks to increase the water capacity per cycle and reduce operating cost.

___ 48. Showers - Take showers rather than tub baths. The average shower takes only one-half the hot water of the average bath. Also reduce the length of the shower.

OUTDOOR EQUIPMENT

___ 49. Power Equipment - Keep garden tractors, snow blowers and other lawn and garden equipment in good operating condition. Savings in energy can also be made by proper operation of this equipment. Read the operator's manual.

___ 50. Roof Heating Cables - Electric heating cable used to prevent ice dams on roofs should be operated only when the temperature is between 15° and 32°F and there is snow on the roof. It costs about 1 1/2 cents per foot of eaves per day to operate this equipment. Limiting its use to only when it is needed will help reduce your electric bill.

NOTE: Current prices would indicate the inflationary markup for this period from 1978 to 1982.

More information on the above subjects may be obtained by contacting one of the following University of Connecticut Cooperative Extension Service Energy Associates:

Lynn Dobieski
Route 6, Stony Hill
Bethel, CT 06801
Tel. 748-8756

Shirley Bethune
Extension Center
Brooklyn, CT 06234
Tel. 774-1658

Lorraine Scotto
Extension Center
Haddam, CT 06438
Tel. 345-2695

Barbara Muir
John Ruckes
1280 Asylum Avenue
Hartford, CT 06105
Tel. 232-4972

Connie Lawlor
Extension Center
Litchfield, CT 06759
Tel. 567-0298

Duncan Bailey
562 New London Turnpike
Norwich, CT 06360
Tel. 886-2167

Catherine MacDuff
24 Hyde Avenue
Vernon, CT 06066
Tel. 871-1604

Bruce Wilbur
649 Howard Avenue
New Haven, CT 06519
Tel. 789-7136

Other Sources are:

Lumber and Building Material Suppliers
Heating Equipment Suppliers
Fuel Suppliers
Electric Company
Appliance Store or Manufacturer

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Connecticut Agricultural Extension Service, E. J. Kersting, Director, Storrs, Connecticut. Issued in furtherance of the Acts of Congress of May 8 and June 14, 1914.

Connecticut Energy Extension Service

78-54

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HOW TO SAVE MONEY WITH STORM DOORS AND WINDOWS

You may be able to cut your heating bill in half if you don't now have storm windows and storm doors on your house. Even if you do have storm windows and doors, they might not be giving you the best protection.

This Fact Sheet will show you how to save money on your heating bill—and it will help with summer cooling, too.

The key to success in weatherizing windows and doors is providing a dead air space between panes of glass or plastic (an air gap between ¼ of an inch and 2 inches is satisfactory, but a ¾-inch gap is best). Any of the following methods will be useful in providing this air space.

INSULATED GLASS

An excellent permanent solution is to use insulated glass windows (sheets of glass with an air space between) in place of single panes. You can get several good insulated windows on the market. They are the most practical for new construction. Cleaning insulated glass windows is easier than cleaning storm windows; however, insulated glass is more expensive to replace when broken.

STORM WINDOWS

Either prefabricated metal windows or wooden storm windows will do the job.

The metal storm windows usually come completely assembled and ready for installation. You will probably have to make adjustments when you install the windows. These units usually are displayed where they are sold so you can examine them closely before you buy. If you install your own units, carefully follow instructions from the dealer.

Wooden storm windows are just as useful but require periodic painting and space for summer storage.

Most storm window frames for windows have either two or three tracks for the up-and-down movement of glass and screen inserts. Regardless of the number of tracks, you should be able to remove all the inserts from the inside of the house.

The triple-track frame allows you to move all the inserts separately to up or down positions. You can also remove them separately from the frame. Although triple-track frames are more expensive, their free movement of inserts does permit you to clean and ventilate easier at either the top or bottom of the window. You can also get frames with inserts that you can tilt in.

In the double-track frame, the screen insert is under the outside top glass insert and supports it. You can raise or lower the bottom glass insert for ventilation. You must remove the screen from the outside track before you can remove the upper outside glass insert from the frame.

Factory-built storm windows or panels for casement, sliding, awning, and picture windows require special designs, depending upon the style of the original window. You can insulate most windows of this type by removing the screen panels and replacing them with glass or plastic panels on the inside of the existing window.

Storm windows also are available for basement casement windows which open either to the inside or outside of the basement.

PLASTIC COVERS FOR DOORS AND WINDOWS

Plastic, can give you the same effective insulation as permanent storm units. You can either use the plastic to cover your present doors, windows, or screens; or you can mount the plastic covering on its own separate fitted frame.

Plastic comes in rolled sheets or is already cut and packaged in kits that include tacking strips, tacks, and instructions for installation. The plastic film varies in thickness, clearness, and resistance to deterioration by sunlight. Polyethylene, for example, is cloudy, flexible,

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and usually lasts only a year. Vinyl sheets, on the other hand, are clear, flexible, and last from 2 to 3 years in direct sunlight. Polyester film is clear and rigid, but might rattle when the wind is high—it is usually finished in 7-mil thickness and stays clear from 6 to 7 years or longer. Plastic sheets of the same thickness as glass are available and can be effectively used in place of glass; however, it is not nearly as scratch resistant as glass. During the warm months plastic may have to be removed for ventilation.

STORM DOORS

You can get several styles of prefabricated metal storm doors. Pick one that suits the style of your house. Look especially for strength and rigidity of framing. Combination screen and storm doors are popular. Self-storing glass panels that slide out of the way for ventilation are convenient but will probably cost more.

Buy storm doors with tempered safety glass or non-breakable rigid plastic to reduce breakage hazards. A grill or bar across the door at the point where your body is most likely to press against the door will also help reduce breakage.

Kickplates at the bottom prevent damage from continued use. Automatic closing devices and strong safety springs are important, particularly in windy locations. Wooden storm doors are equally as effective as metal storm doors if not slightly more so, but they require painting.

COST CONSIDERATIONS

Plastic is the least expensive way to winterize your windows and doors. If you can't afford to do your whole house (whether with plastic or permanent glass units), do the side of the house that faces the prevailing winter winds. If you can afford permanent storm windows and doors, you'll probably find them more economical than plastic ones in the long run. Permanent storm windows and doors, while more expensive, add value to the property. Plastic units do not.

POINTS TO LOOK FOR IN STORM DOORS AND STORM WINDOWS

When you select storm doors and windows, consider the following points:

- The strength of the main frames and frames for the glass or screen inserts is important. Also look for good design to assure easy and efficient handling.
- Look for weathertightness to prevent the entrance of water, cold air, dust, and insects. However, an opening or weep system is standard at the base of all storm windows to release excess moisture.
- You should be able to remove the glass and screen inserts from inside the house. This makes house cleaning easier and requires no outside climbing.
- Think ahead to possible repair problems. Does the dealer offer repair service or can you get replacement parts and do the repairs yourself?
- When you buy new units, check to see that you have all the hardware: hinges, closers, wind chains, locking latches, vinyl base weatherstripping and screws. Check for quality and sturdiness.
- Are materials, workmanship, finish, and assembly under warranty for an adequate period?
- Select the appropriate finish to match your exterior finish.
- When metal framed storm panels are placed on metal storm windows, use a gasket to prevent metal-to-metal contact.

HOW TO AVOID MOISTURE PROBLEMS

You'll have less condensation on the inside surfaces of glass panes when you install storm doors and windows. There might be some condensation if you draw drapes or shades at night or if the inside air is especially moist. Remember that while plastic storm covers should be snug, they need not be completely air tight. Weep vents in aluminum storm windows also allow a small circulation or air, thus preventing condensation.

Weatherstripping on sashes of the house windows can prevent moisture condensation inside the storm windows. See your materials supplier for the best materials for your needs. Insulating storm panels or plastic films placed inside the house should be well sealed around the edges to prevent warm damp air from getting between the inside window and the storm window.

OTHER ADVANTAGES OF STORM WINDOWS AND DOORS

- They reduce cooling needs in the summer as well as heating costs in the winter.
- They reduce the noise entering your home.
- They cut down on drafts.
- Self-contained units provide storage space for inserts not in use.

United States Department of Agriculture
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2

energy facts

The value of storm windows and doors

save Energy save Dollars

The University of Connecticut
Cooperative Extension Service,
Storrs, Ct. 06268

Windows and doors cover 20 percent of the sidewalls in an average home. Heat losses through and around windows and doors may be responsible for as much as 50 percent of your fuel bill.

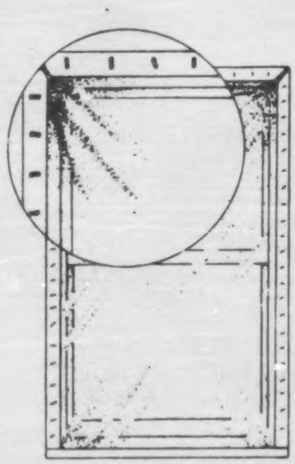
Storm windows and storm doors cut heat loss by creating dead air space between exterior and interior windows and doors. This air space–it should be at least 3/4"–is the actual energy saver. In the north, where severe winters are common, you can realize 10 to 30 percent savings in heating costs by installing tight-fitting storm windows and doors. Cover all windows and entries to heated areas of the home.

There are three basic types of storm windows and doors: plastic, single pane, and combination screen and storm (triple track combination). To be worthwhile, all must be installed with weather stripping or gaskets along the crack between the storm unit and the window or door frame.

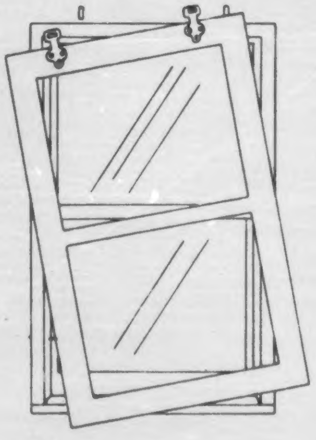
Plastic sheeting of at least 6-mil thickness can be cut slightly larger than the area to be covered and attached to the window or door with masking tape, or preferably, 1/4" wood slats. Damage from ice and wind can be avoided if the plastic is mounted on the inside of the window. Usually, the installation of plastic storm sash is a do-it-yourself job. It is economical and efficient for renters and homeowners. If used on the outside of the window, new plastic should be installed each year. If used on the inside, several years' use from the plastic may be possible.

Single pane storm windows and doors are usually stored during the summer and put on each winter. Check seasonally and replace cracked putty. Paint regularly to preserve the wood frame.

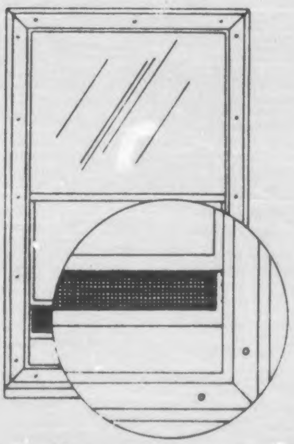
An experienced contractor is the usual source for single pane storm windows and doors. However, if you are skilled in car-



Plastic sheeting



Single pane



Combination storm and screen

pentry, you can make them. Windows and doors are not projects for the beginning do-it-yourselfer. A thorough window insulation job with plastic and weather stripping is more effective than ill-fitting, single pane storm sash.

Combination screen and storm windows and doors remain permanently in place. Self-storing screens are incorporated into the units. Therefore screens and storms can be interchanged easily. Combination units are available in steel and in plain and baked aluminum finishes. The baked aluminum finish requires the least maintenance and is the most durable. Properly fitted combination units have vents in the frame where the storm sash meets the sill. These vents keep condensation from collecting and causing rot and should always be kept clear. If your present combination units do not have such vents, you should drill them into the frames.

The construction and, usually, installation of combination storm windows and doors are jobs for an experienced, reputable contractor. The marketplace abounds with combination units of varying quality and cost; check out several before you buy. Be watchful for the quality of hardware, corner joints, and weather stripping. For safety's sake, insist on safety glass or rigid plastic for storm doors.

Once your choice is made, a contract between you and the contractor should be signed before work is begun. The contract should specify materials, cost, work content, and warranty.

Financing and Long-Term Savings

Storm windows and doors conserve energy as well as add to the value of a home. You may wish to finance the installation of storm windows and doors with a home improvement loan, currently available for up to five years. Obtain estimates before visiting a bank.

It is estimated that storm windows and storm doors will pay for themselves in seven to ten years or less depending on energy costs (based on 12% interest charges). After that, they will return a dividend of 13 to 18 percent. A smart way to save energy and dollars!

For more information ask one of the following offices:

Fairfield County 748-8756
Route 6 — Stony Hill, Bethel 06801

Hartford County 232-4972
1280 Asylum Avenue, Carriage House, Hartford 06105
or 19 High Street, Bristol 06010 584-2387

Litchfield County 567-0236
Agricultural Center, Litchfield 06759

Middlesex County 345-2695
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New Haven County 789-7136
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24 Hyde Avenue, Vernon 06066

New London County 886-2167
562 New London Turnpike 06360

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

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The following chart compares the three basic types of storm windows and doors:

Types of Storm Windows and Doors

	Plastic	Single pane	Combination
Initial cost	low	medium	high
Durability	low	medium-high	high
Maintenance – time	high	high	low
Maintenance – cost	medium	medium	low
Visibility	low-medium	high	high
Ease in opening	low	low	high
Ease of installation	low	medium	medium

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Energy Outreach *A joint effort of the*
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and the Connecticut Energy Division

Energy Outreach Offices

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232-4972

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789-7136

562 New London Turnpike
Norwich, CT 06360
886-2167

SAVE HEATING AND COOLING DOLLARS WITH WEATHERSTRIPPING AND CAULKING

The time and money you invest in weatherstripping and caulking windows and doors can pay off faster than almost any other home improvement you can make, even when your house is already well insulated. From 15 to 60 percent of the heating or cooling your house needs is due to air exchange. Warming the air that leaks into the house in winter, or conversely cooling the air that leaks into it in summer, takes energy and costs you money. Besides keeping out moisture, wind, and hot or cold air, weatherstripping will block entry to dust and noise, resulting in a cleaner, quieter home. Both weatherstripping and caulking are easy, economical, do-it-yourself jobs.

WEATHERSTRIPPING DOORS AND WINDOWS

Weatherstripping may be purchased by the foot or in handy kits complete with the seal and fasteners for a single door or window. Installation instructions and diagrams are provided on most weatherstripping packages. Some weather seals are surface mounted and are visible, while others are concealed when the door or window is closed. They may be made of a variety of materials.

Self-Adhesive Foam Tapes — High-grade resilient sponge rubber or vinyl with paper or vinyl backing in thicknesses up to three-eighths of an inch and widths up to three-quarters of an inch. Backing is peeled off as tape is pressed in place on door and window jambs, stops, or sash. Surfaces must be clean and dry; should be applied at room temperature for best adhesion. Low cost; easy to install; foams tend to deteriorate when exposed to weather; may last only one season.

Felt Weatherstrip— Low-cost material in various widths and thicknesses. Fasten to wood by tacking or stapling and to metal with a good adhesive. Must be applied to door stop, sill, or sash so it fits snugly against other member. Easy to apply; tears easily during use; not as effective when wet.

Aluminum and Felt Strip— Aluminum strip crimped to thin felt strip provides added strength for tacking and holding to door jambs and window stops. Can be used for round-top doors. Felt may tear during normal use, especially on doors; felt not as effective when wet.

Vinyl Weatherstrip— General-purpose moisture and temperature resistant strip easily applied to wood or metal with tacks, staples, screws, or a good commercial adhesive. Tube-shaped for a tight fit, with extended strip for stapling or bonding to door and window jambs, stops, or sash. Easy to apply; durable.

Sponge Rubber Neoprene-Coated Strip — Round, high-quality durable sponge rubber with a spring steel reinforced strip for attachment. Provides exceptional holding strength when tacked or stapled. For bottom of door, fasten to door; for sides, fasten to door jamb. Also used on windows by fastening to appropriate frame, stop, and sash. Easy to install.

Bronze Weatherstrip— Thin bronze strip in various widths with one side flared out. Tacked to door jamb so when door is closed strip presses against the flared side making a tight fit. Also used for casement windows; not suitable for double-hung windows except at top and bottom. Low cost; easy to install; durable; not affected by moisture or temperature.

Door Bottom Strip— Brass-plated steel crimped to felt or vinyl strip. Fasten to lower edge of door with screws or small nails. Easy to apply; vinyl more durable; felt tears easily and is not as effective when wet.

Weatherstrip and Caulking Cord— Five or six caulking cords in a strip for sealing cracks in windows, doors,

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and around room air conditioners. Applied by pressing in place. Cord stays pliable and adheres to any surface. Low cost; easy to apply; durable, not affected by moisture.

Waterproof Weatherstrip Tape— Self-sealing, transparent, durable polytape for sealing cracks in any location. Easy to use by pressing to a clean, dry surface. For windows, tape applied half on stop and half on sash.

Sponge Rubber Door Bottom Seal— Mainly for garage doors, a blend of high-quality sponge rubber that stays flexible at extremely low temperatures. Applied to bottom of door with wide lip outside; if garage floor is lower than driveway, wide lip applied inside.

Air Conditioner Weatherstrip— Rectangular polyfoam that press-fits between the top frame or lower sash and upper pane to seal off the air spaces between window and air conditioners. Low cost; easy to install.

Fiber Glass Insulation Strip— Insulation strip in various sizes used with waterproof tape for closing large cracks around basement and garage doors, windows, and other cold air leaks. Also wrapped around hot water pipes for insulation.

Door Bottoms— Door bottom weatherstripping is available in several materials. While easy to apply, these products can interfere with door swing and require a reasonably level threshold beneath the door. Only simple handtools are required to install any of these door bottoms. After cutting to size with a hacksaw or tin snips, the door bottom is surface mounted to the inside of the door using wood screws normally provided by the manufacturer.

A fairly new innovation in weatherstripping is the mechanically operated "automatic" door bottom. In this model a vinyl seal is automatically lowered against the floor when the door is shut. The seal retracts when the door is opened.

Thresholds— A more attractive method of windproofing the bottom of a door is with a threshold. While most thresholds are effective at cutting down wind infiltration, the average homeowner may find them difficult to install.

A popular threshold is an aluminum model with a flexible vinyl "bulb." When new, this threshold is effective; but under constant use the bulb soon collapses, leaving a sizable crack beneath the door. In most cases the vinyl is replaceable.

Though not the easiest type to install, the combination vinyl door bottom and aluminum threshold is long-wearing and provides effective weatherproofing. Since the vinyl is mounted in an aluminum extrusion fastened to the door, the aluminum threshold bears the brunt of wear.

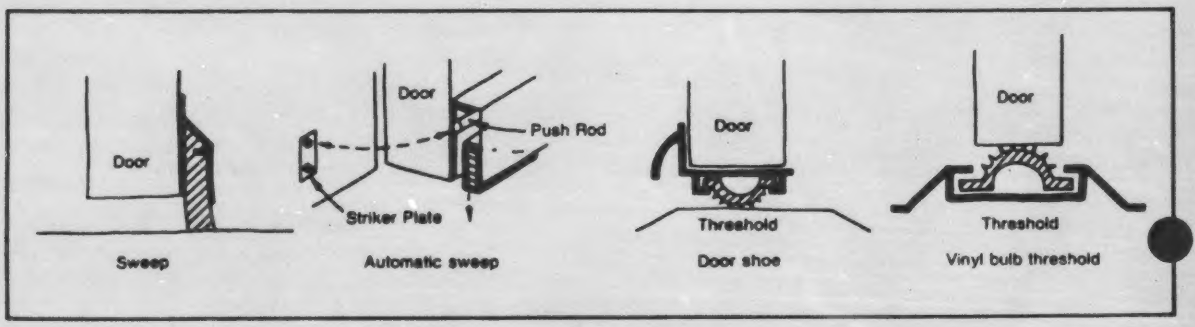
CAULKING

Do-it-yourselfers will find many caulking compounds in a wide range of prices. Most materials are packed in cartridges and can be applied easily with a caulking gun. For large jobs, 5-gallon containers of caulking for guns are used. Manufacturers usually print on each cartridge a description of the material, its performance quality, and directions for application.

Caulking materials that adhere to wood, glass, metal, plastic, and masonry should be selected since these materials expand and contract. Resistance to weathering, cracking, shrinkage, water, and mildew are als important. Some manufacturers will state the life expectancy of their product if properly installed inside or outside the home.

High-quality caulking compounds with a long life expectancy are generally the most expensive. Assuming that the caulking material is used outside as directed by the manufacturer, the following years of useful life may be expected: Silicone—30; polysulfides, polyurethanes, neoprene, acrylic (solvent release), vulcanized butyl rubber—20; acrylic-latex, butyl rubber, and synthetic caulking compounds—8 to 10; cheaper caulking compounds—3 to 5. This is only a partial list and is not meant to exclude any product.

Caulking should not be applied at temperatures below 40° F. It should be installed when temperatures range

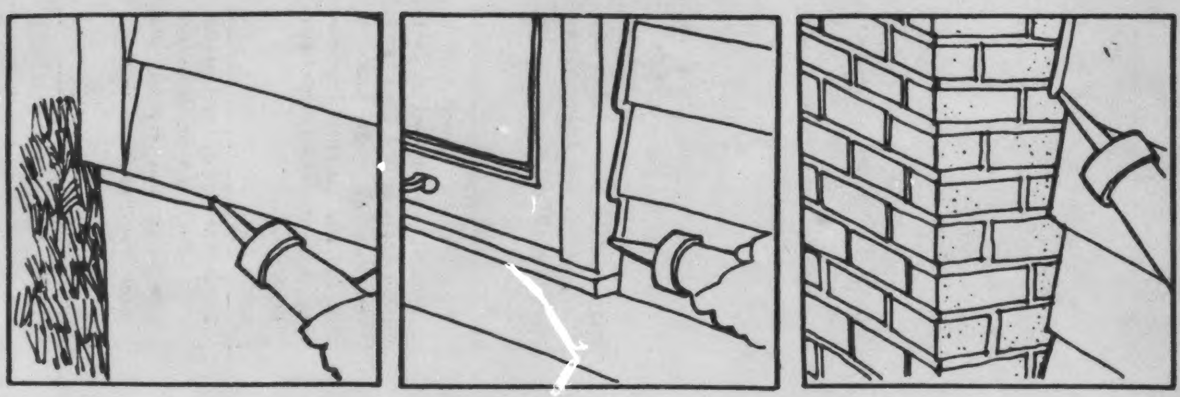


Sweep

Automatic sweep

Door shoe

Vinyl bulb threshold



between 45° F and 55° F. At these temperatures expansion and contraction at joints are at a midway point.

Surfaces to be caulked should be clean, dry, and grease-free. Remove dust, loose particles, and old caulking. A steel brush is a good tool for cleaning joints. Refer to the manufacturers' recommendations for caulking large cracks.

Sealing Cracks and Seams—Sealing exterior cracks and seams is an important part of home maintenance. It reduces entry of air, dirt, and moisture into the house and contributes to lower heating and cooling costs.

Among the most important exterior areas of a house requiring attention are:

- Chimney flashing
- Joints between chimney and siding
- Joints between eaves and gable molding
- Joints between window sill and siding
- Joints between window sash and siding
- Joints between window drip cap and siding
- Joints between windows and masonry
- Door frames
- Joints between masonry or concrete parts (steps, porches, etc.) and main part of house
- Inside corners formed by siding

APPLYING SEALING MATERIALS

Follow these pointers for successful application of sealing materials:

- Remove old, dried sealing materials. Clean area with a solvent to remove grease or other substances that would prevent a tight bond.
- Deposit sealing material at the bottom of the seam so it fills without bubbling.
- Never apply sealing material to a porous surface.
- Prime before application.
- Never skimp. Use enough sealing material to fill the crack or seam.
- If sealing material shrinks during drying, reapply.

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USES AND PROPERTIES OF COMMON SEALING MATERIALS

Material	Recommended Uses	Cleanup Solvent	Shinkage	Adhesion	Remarks
Silicone Household	Seals joints between bath and kitchen fixtures and tile; adhesive for tiles and metal fixtures; seals metal joints as in plumbing and gutters	Dry cloth will remove if area is cleaned up immediately. Use mineral spirits or naphtha	Little or none	Good to excellent	Readily available. Flexibility of cured silicone allows stretch of joints up to three times normal width or compression to one-half the width. Cost: High
Silicone Construction	Seals most dissimilar building materials (i.e., wood and stone; metal flashing and brick)	Same as above	Same as above	Same as above	Remains flexible for life after curing. Permits joints to stretch or compress. Silicones will stick to painted surfaces, but paint will not adhere to cured silicone. Cost: High
Butyl Rubber	Seals most dissimilar materials (glass, metal, plastic, wood, concrete). Seals around windows and flashing, or bonds loose shingles	Use mineral spirits or naphtha	From 5 to 30 percent	Good	Less resilient than silicones. Allows for joint movement but does not become brittle with age. Can be painted after skin forms. Apply when temperature is above 40° F. Cost: High
Latex	Seals joints around tub and shower; fills cracks in tile, plaster, glass, and plastic; fills nailholes	Use water	From 5 to 10 percent	Good to excellent	Easy to use. Seams can be trimmed or smoothed with moist finger or tool. Good water resistance when dry. Can be sanded and painted. Less elastic than above materials. Easy to clean up. Cost: Moderate
Oil-Base Caulks	Seals exterior seams and joints on building materials	Use mineral spirits or naphtha	From 10 to 20 percent	Good	Readily available. Least expensive of the four types. Rope and tube form. Oils dry out and cause material to harden and fall out. Cost: Low

Agriculture Fact Sheet 2-3-2 April 1978

United States Department of Agriculture
Office of Governmental and Public Affairs
Washington, D.C. 20250

CONNECTICUT COOPERATIVE EXTENSION SERVICE

10

energy facts

Water heating: use and conservation

save
Energy
save
Dollars

The University of Connecticut
Cooperative Extension Service,
Storrs, Ct. 06268

Hot water is taken for granted and looked upon as an integral part of most American households. Little thought is given to the cost of heating water because its use is constant rather than seasonal, as with a central heating system.

The heating of water accounts for a whopping 15 percent of your total energy bill. You can't do without hot water, but there are several ways to conserve it so that energy requirements and costs will be less.

Equipment

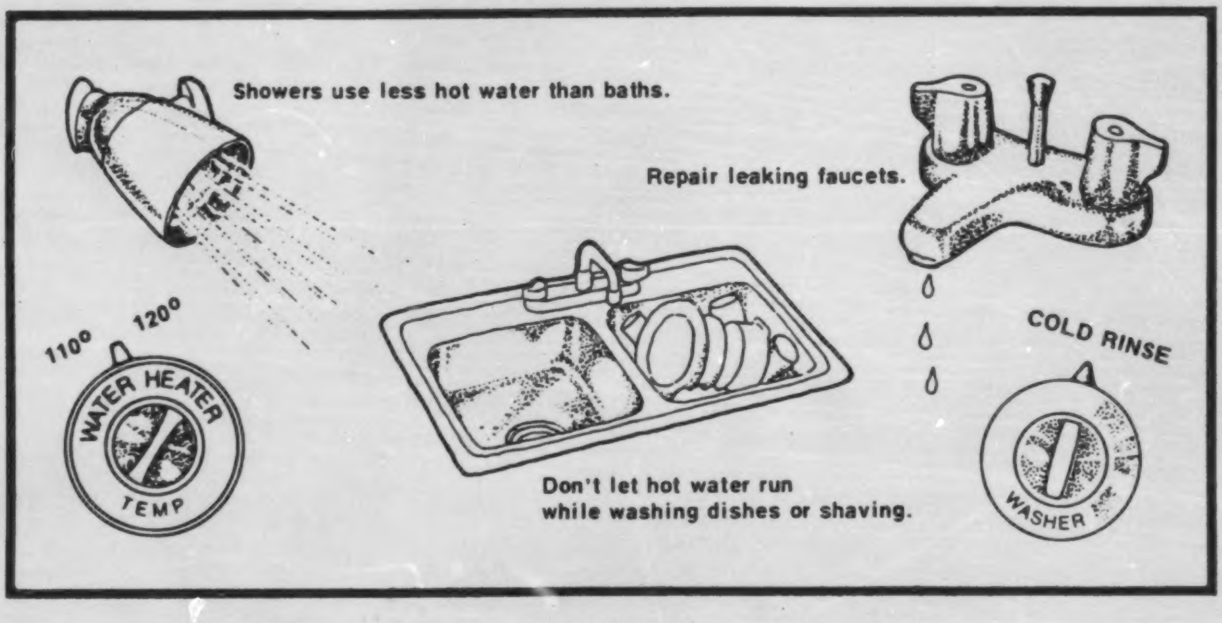
Hot water usage depends on the number of people in a household, the number of bathrooms, and on the presence and regular use of a clothes washer and/or automatic dishwasher. Water heating units, usually using gas, electricity, or oil, are specified in terms of tank size, rate of heat input, maximum estimated hot water usage per hour, and recovery or reheating capacity, rated in gallons per hour. An oversized unit uses energy to keep unneeded water hot; an undersized unit cannot supply a sufficient amount of hot water. A reliable heating and plumbing contractor can determine the size tank needed in your household.

If you must replace a water heater, make energy efficiency your main criterion. Look for information indicating how efficiently the unit uses the energy required for operating it. Also look for a thickly insulated outer shell. When replacing a gas-fired unit, select one with an electric ignition system. These units eliminate pilot lights—energy wasters.

Relocate the unit, if necessary, as close as possible to areas of major hot water use. Use small diameter pipes for hot water supply lines to minimize heat loss and to reduce the volume of trapped water.

Thermostat Setting

A thermostat setting of 110°-



Showers use less hot water than baths.

Repair leaking faucets.

Don't let hot water run
while washing dishes or shaving.

120°F on a water heater is sufficient if you do not have an automatic dishwasher. A setting of 140°F is recommended if you do have one. Temperatures over 140°F shorten the life of a glass-lined tank.

Maintenance

Twice a year (monthly if you live in an area with heavy mineral deposits in the water) empty a bucket of water from your hot water storage unit. This will help remove sediment which insulates the tank from the source of heat and wastes energy.

Stand-by Losses

Heat losses from a hot water storage tank and supply lines can be significant. You can reduce losses by wrapping unfaced batt or blanket insulation around and over the shell of the tank.

Pipe insulation is needed especially where pipes run through unheated areas such as basements and crawl spaces. Several types of insulation for wrapping or covering pipes are available at hardware and building supply stores. Insulate cold-water pipes as well in these areas to reduce the chance of winter freeze-up.

A leaking hot-water faucet is an enormous waster of energy and should be repaired immediately. The replacement of washers is a simple operation described in every basic home-owner's maintenance and repair guide. A faucet that leaks one drop per second wastes 2,400 gallons of hot water each year. That's enough to run 160 full cycles on an automatic dishwasher!

"Off-Peak" Water Heating

Some utility companies offer a special or "off-peak" rate to customers in an attempt to reduce electric demands, thus avoiding the need to put into use back-up generating equipment which is usually less energy efficient. Such rates, if available, apply during evening hours and are lower than rates for peak use. They require special equipment and a separate meter. By gearing hot-water use to off-peak hours, it is possible to reduce the amount of money you spend for water heating.

Even if your utility company does not presently offer an "off-peak" rate, try to reduce your peak hour hot-water demands. Take showers, do laundry, and run the dishwasher before 7:00 A.M. or after 8:00 P.M. or on weekends when there is less generating demand on utilities. Such practices will not lower your utility bill, but they will help conserve energy and will reduce the need for building additional generating capacity which, currently, is very costly.

Hot Water Conservation Tips

A simple rule of thumb applies to energy conservation and hot water: every time you use cold water instead of hot you save energy and dollars. The following tips will help remind you of ways to reduce hot water consumption.

- Wash only full loads of laundry. Use water level or load size devices on your clothes washer.
- Use as low a water temperature as possible for the wash cycle of your clothes washer. Use cold water for all rinse cycles. Presoak heavily soiled clothes before washing.
- Scrape dishes before placing them in a dishwasher. If rinsing is necessary, use cold water.
- Try to run your dishwasher no more than once a day or only when fully loaded. Between meals, store soiled dishes in the unit.
- When washing dishes by hand, fill a pan with hot water for rinsing. Don't let hot water run continuously.
- A flow restrictor can be purchased for as little as $1.50. Easily installed in a shower head, this device reduces the amount of water flowing from the pipe (but not the pressure) from 5 gallons per minute to 3.
- Take quick showers instead of baths; they use up to 50 percent less hot water.
- Don't let hot water run continuously when you shave. Close the drain and fill the basin with water instead.
- Turn down your water heater thermostat to a minimum setting if you plan to be away from home for an extended period of time.

For more information ask one of the following offices:

Fairfield County 748-8756
Route 6 — Stony Hill, Bethel 06801

Hartford County 232-4972
1280 Asylum Avenue, Carriage House,
Hartford 06105
or 19 High Street, Bristol 06010 584-2387

Litchfield County 567-0298
Agricultural Center, Litchfield 06759

Middlesex County 345-2695
Extension Center, Haddam 06438

New Haven County 789-7136
649 Howard Avenue, New Haven 06519

Tolland County 871-1604
24 Hyde Avenue, Vernon 06066

New London County 886-2167
562 New London Turnpike 06360

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NOTE: These fact sheets are adapted from a series published by the New York State College of Agriculture and Life Sciences and the New York State College of Human Ecology, Cornell University, Ithaca, N.Y.

AFS - 2 - 3 - 4

FACT SHEET

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

UNITED STATES
DEPARTMENT
OF AGRICULTURE

ENERGY
CONSERVATION
IN THE RURAL HOME

SOLVING MOISTURE PROBLEMS WITH VAPOR BARRIERS AND VENTILATION

When you install insulation—or "weatherize" your home in other ways—you may alter the movement of moisture through the walls, ceilings, and floors. Signs of undesirable moisture movement are: peeling paint, water stains in the attic, or an extremely damp crawl space. Trapped moisture invites decay and insects.

Moisture which gets into insulation also increases the rate of heat loss; therefore, you should control moisture as an essential part of your own energy conservation plan.

During the heating season, warm indoor air holds more moisture than cold outdoor air (fig. 1). This creates vapor pressure inside, which constantly forces water vapor out through walls and ceilings as it seeks lower moisture levels outside. When moisture levels within walls, attics, or crawl spaces become high, the water vapor tends to condense on cold surfaces. In most structures moisture can escape to the outside, but if moisture moves into the walls, ceiling, or crawl space faster then it can escape to outside air, the moisture will build up.

Here are three things you can do to control moisture buildup: (1) control humidity in the house; (2) install vapor barriers in walls, floors, and ceilings; and (3) ventilate attics and crawl spaces.

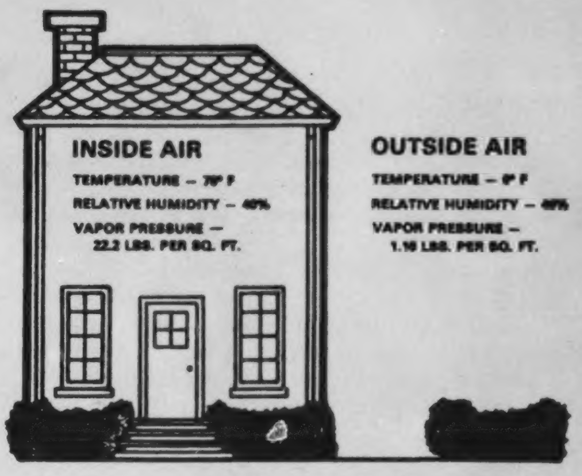

Figure 1. Vapor pressure difference between indoors and outdoors causes the movement of moisture into the walls.

CONTROL HOUSEHOLD HUMIDITY

In cold climates, set your indoor controls for relative humidity in the winter no higher than 35 to 40 percent. When outdoor temperatures are 20° F or lower, reduce the humidity to less than 35 percent. Although a higher humidity might be healthier and might improve the performance of your heating system, it could cause serious condensation problems in your home. When condensation develops on insulated glass windows, you know that the relative humidity is definitely too high.

You add to the moisture level inside your home by bathing, cooking, and doing laundry. These activities can raise the humidity level too high. Exhaust fans in baths and kitchens will help eliminate this moisture before it spreads through the house. Clothes dryers should be vented to the outdoors. If high humidity persists, you might consider using a dehumidifier, even in winter. This, however, would be necessary only in an exceptional situation.

If your home is too dry, use a humidifier. Set the controls no higher than the humidity that is recommended for your climatic zone. Watch the windows and cut back the humidifier if you see excessive condensation forming on them. Major humidifier manufacturers provide a schedule of settings that are appropriate for outdoor temperature levels.

VAPOR BARRIERS

A vapor barrier is any material that effectively slows the movement of moisture from a point of high vapor pressure to one of lower vapor pressure—such as from the inside of a warm home toward the outside cold air. Vapor barriers should always be placed near the warm side of the wall, ceiling, or floor. Materials near the cold side should permit moisture to escape out of the wall or ceiling to the outside. A vapor barrier that is placed on both the inside and outside of a wall will trap moisture and invite decay.

Small vents installed near the top and bottom of stud spaces will allow moisture to escape where no vapor barrier is used. In some instances, however, these vents may result in higher moisture in the insulation because cold air entering the cavity moves the dew point (the temperature at which condensation occurs) toward the warm or house side of the cavity. The vents do reduce moisture levels near the siding or outside wall. This may help prevent peeling of paint, even though there is a greater heat loss.

Blanket insulation with a vapor barrier backing is frequently used in new walls. Tabs of the backing should always be attached over the edge of studs with tabs lapped. Additional strips should be used over uninsulated areas such as window framing. Without this lap, moisture can enter the walls between adjoining insulation blankets. This is something to discuss with the builder.

Another commonly used vapor barrier in new buildings is polyethylene film in large rolls. The film is applied continuously over the inside face of studs, over the bottom of ceiling joists, and on top of floor joists over a crawl space. Such a film has the advantage of being continuous so the only gaps are where holes are cut for openings such as windows and electrical outlets. These holes should be cut carefully to prevent as much moisture leakage as possible.

It is difficult to add a vapor barrier to existing construction. Often older homes have several coats of oil-based paint on walls, and this may serve as an adequate vapor barrier if you maintain reasonable household humidities. However, the only way to be certain of an adequate barrier is to add a vapor barrier to the walls and apply new paneling or other drywall over the barrier. Attics and crawl spaces can generally be vented enough to carry moisture out, so barriers in floors and ceilings are not as critical as barriers on walls.

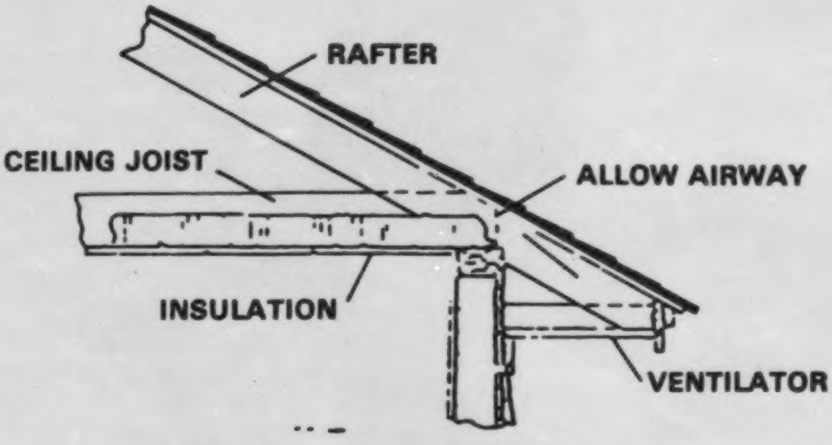

Figure 2. Airway at eave must not be blocked by insulation.

A major source of moisture in houses can be eliminated almost completely by placing a vapor barrier over the soil in a crawl space. This prevents deterioration of floor framing because of high moisture levels, and keeps moisture from moving up through walls and to living areas.

VENTILATION

The main areas requiring ventilation are attics and crawl spaces. In both instances it is necessary to have a good distribution of air movement over the entire area. Attic ventilation is essential. Without it, moisture that moves through the ceiling will be trapped in the attic because most roofing materials prevent moisture from escaping. Flat roofs or cathedral ceilings also must provide for ventilation between the insulation and the roofing.

You can provide attic ventilation with inlet vents distributed along the eave, and with outlet vents near the ridge. Eave vents must not be blocked by ceiling ventilation (fig. 2). Warm air in the attic rises and escapes through the ridge vents; cooler outside air enters at the eaves (fig. 3). Thus, the ventilation is continuous and does not depend on the wind. This ventilation also slows the melting of snow from the roof in cold climates, reducing the possibility of ice dam problems. In the summer, such ventilation reduces buildup of heat in the attic which, otherwise, would cause uncomfortably high temperatures in the house or, at least, higher air conditioning costs. For adequate ventilation, the area of inlet vents each should be at least 1/900th of the ceiling area. Outlet vents also should be at least 1/900th of the ceiling area. Where vents are provided at only one level, such as at gable ends, the total of all the vent areas should be at least 1/300th of the ceiling area.

Crawl spaces should be vented to the outdoors. If the vents are located near each corner, the vents will permit good air movement through the crawl space. The total of all the vent areas where there is no vapor barrier as a ground cover should be at least 1 square foot for each 150 square feet of floor area. Where such a vapor barrier is used, the vent area may be reduced to 1/1500th of the floor area.

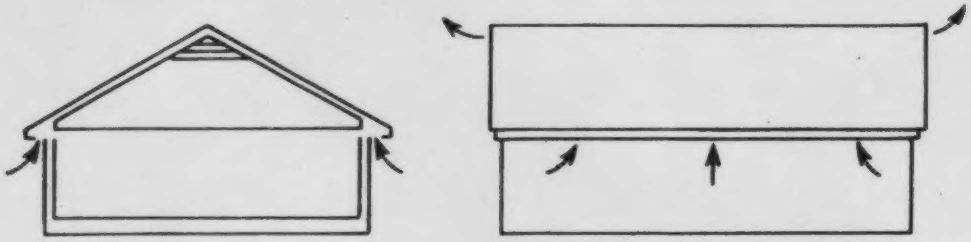

Figure 3. Inlets at eave, outlets at ridge for good ventilation.

Fact Sheets In The Home Weatherization Series

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3. Save Heating And Cooling Dollars With Weatherstripping And Caulking
4. How To Save Money With Storm Doors And Windows
5. What To Look For In Selecting Insulation
6. How To Install Insulation For Ceilings
7. How To Install Insulation For Walls
8. How To Install Insulation For The Floor And Basement
9. Solving Moisture Problems With Vapor Barriers And Ventilation
10. Weatherize Your Mobile Home To Keep Costs Down, Comfort Up
11. Tips On Financing Home Weatherization
12. Keeping Home Heating And Cooling Equipment In Top Shape
13. Landscaping To Cut Fuel Costs
14. Home Management Tips To Cut Heating Costs
15. Locating New Home Sites To Save Fuel

Single copies are available upon request to Special Reports Division, Office of Governmental and Public Affairs, U.S. Department of Agriculture, Washington, D.C. 20250.

This series of fact sheets was assembled from research, Extension, and other sources by the USDA Task Force on Weatherization.

Agricultural Fact Sheet 2 - 3 - 4
United States Department of Agriculture
Office of Governmental and Public Affairs
Washington, D.C. 20250

May 1978

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

AFS-2-3-7

FACT SHEET

UNITED STATES
DEPARTMENT
OF AGRICULTURE

**ENERGY
CONSERVATION
IN THE RURAL HOME**

Keeping Home Heating and Cooling Equipment In Top Shape

Proper selection, installation, and maintenance of your heating and cooling system can save you money, improve comfort in your home, and improve reliability. When selecting a home heating and cooling system, explore all the available alternatives.

Don't Heat or Cool Space Not Being Used

Perhaps you can operate your home more efficiently by changing your current heating and cooling routine. If you can get along without heat in some areas of your house, turn it off. Some rooms or areas may need only a minimum amount of heat; others may need heating or cooling only occasionally. Regulating the heating in this way can reduce your energy costs significantly.

When practical, heat or cool the rooms in the center of the house and let the outside rooms serve as an insulating barrier.

You can adjust the heating and cooling in rooms by opening and closing registers. If your registers aren't adjustable, consider replacing them. If you have a water system or steam radiators that can't be turned off, install bypass lines or shutoff valves as needed to control the system and protect it against freezing. Thermostatically controlled valves in each room provide the most effective system.

In large homes single-room heating units can help to reduce demand on a central system. The central unit can be operated at a low temperature setting throughout the house while the small units can boost the temperatures in rooms being used the most.

Adjust Thermostat

In the Northeastern United States, 15- to 20-percent savings are possible with a reduction of 5° to 8° F in house temperature.

Setting your thermostat down at night to 55° F or below makes sleeping more comfortable. For the forgetful, clock-controlled thermostats can insure that temperature settings are adjusted on schedule.

Regulate Humidity

In the winter heat (or cold) spreads through your home fastest if the air is moist. However, you need humidity to protect your body from dry hot air in the winter. During the summer, you are more comfortable if you reduce the humidity in your home.

You may use humidifiers to add moisture removed by your hot air furnace system. Too much humidity, however, will cause mold-producing dampness and excessive condensation on windows. Dehumidifiers are good for controlling summer dampness, but are not especially good for comfort control.

The sun streaming through windows increases the load on an air conditioner. You can protect against this by blocking the entrance of the sun's rays. Keep drapes, blinds, and shutters closed when the sun is shining directly on them. Install awnings to shade windows. The overhang, or awnings, should extend far enough to provide full shade in summer but let in the sun in winter. Southern exposures need this protection the most.

Room Ventilation

Proper ventilation of your house can reduce or eliminate the need for summer air conditioning. You can use windows, doors (screened), and other natural ventilation or you can use electric fans. Natural ventilation may not be as cooling, but it may be sufficient and cost less than air conditioning. Ventilate your living space in the evening and/or at night. Do not ventilate when your house is cooler inside than out. Keep the cool air trapped. Open vents or windows near the ceiling if you can to remove trapped hot air. Ventilation fans are particularly useful where evening breezes are not strong enough to move air through the house.

Your attic is a heat trap. While it serves as a buffer for the sun's heat, heat from the attic flows into the living area and increases the air conditioning load. Attics reach temperatures above the outside air early in the day. The attic should be ventilated by a fan as soon as its temperature rises above that of the outside to prevent a heat buildup.

Attics can be ventilated by either natural air currents or by fans. Either way, lots of air must pass through to be effective. Roof vents or louvres should provide a lot of open area for natural ventilation. Most homes have minimal louvre openings, only enough to avoid winter mositure problems.

Frequently a combination of soffit, gable, or ridge vents is used to ventilate attics without using a blower. Soffit and ridge vents are quite effective because the airflow is shorter. The ridge vent exhausts at a higher elevation than a gable opening. This creates a strong natural draft. Gable vent efficiency can be improved by locating a new house to permit prevailing winds to flow through the attic. For winter ventilation, the exhaust vent area (a similar area is needed for intake air) is 1 square foot for every 150 square feet of attic space. Effective summer ventilation requires much larger vent areas.

Ridge vents also increase natural ventilation by providing a short, direct airflow through the attic. The rotating cap of the cyclone acts as a low-capacity turbine. It can utilize wind power from any direction.

Powered fans operated from a thermostat reduce attic temperature levels automatically. The cost of operating the blower should be offset by savings in air conditioning loads. This, however, depends on the amount of insulation in the ceiling between attic and living space. The more the insulation, the less necessary a powered fan will be. When ceiling "R" values are high (above 30), it is still economical to install ventilation that operates on natural air currents.

Maintenance and Care of Equipment

The servicing and repair of furnaces usually require the attention of a serviceman. Homeowners can do some regular servicing and maintenance to keep the system operating efficiently. For safety, always keep the area around the furnace free of flammable material. Things the homeowner should check regularly are:

Air Filters Check the air filters of hot air heating systems every 6 weeks during the heating and cooling season. Clogged filters reduce airflow. This reduces effectiveness and increases energy bills. Some filters may be washed. Others must be replaced.

Electric Motors Follow the manufacturer's instructions for lubricating motor and blower bearings. Some bearings are permanently sealed and need no lubrication. Others need three to six drops of light motor oil every 6 months. Overoiling can damage a motor. Be sure oil holes are capped to keep dirt out. Wipe off excess oil or grease. Use clean rags to wipe dirt off the motor and clean ventilation openings. An accumulation of dust and dirt on the motor acts as insulation and may cause overheating.

Fan Belt A fan belt that's too tight causes excessive wear on the bearings. If it is too loose, it will slip, increasing belt wear and reducing blower efficiency. Allow a ¾-inch depression in the belt for each foot of distance between shaft pulleys when the belt is pressed with a finger midway between the pulleys. Check belt tension and alignment every 6 weeks when the air filters are inspected. If a new belt is needed, purchase the proper size and length. When installing a new belt, release the takeup adjustment on the motor and do not roll the belt onto the pulley. Check the vanes on the fan and remove accumulated dirt.

CAUTION: BE SURE THE POWER TO THE MOTOR IS SHUT OFF SO IT WILL NOT COME ON WHILE YOU ARE WORKING ON THE MOTOR, BELTS, OR FANS.

Humidifiers The major service problem with humidifiers results from mineral deposit buildup. This takes frequent servicing to avoid. As mineral deposits build up on the evaporator, efficiency decreases. Evaporator pads or plates should be cleaned or replaced when the buildup of salts interferes with evaporation.

Thermostat Thermostats may get out of adjustment and indicate the wrong temperature. Check the point at which they go on and off against the reading on a thermometer held near the thermostat. If the thermostat is not operating correctly, have a serviceman see if it needs adjustment, repair or replacement.

Registers and Radiators Dust on radiators, convectors, baseboard heating units, or in ducts acts as insulation and wastes heat. Vacuum them regularly.

If you have a hot water system, bleed air from radiators annually; open each radiator valve, hold a cup under it until water comes out. Don't drain the water. You only need to remove the air inhibiting water circulation.

Paint radiators with special radiator paint for best performance. Metallic paints and casings built around radiators reduce heat as much as 25 percent. If radiator covers are necessary, select ones that have grills over at least 75 percent of their surface. Place aluminum foil behind radiators to reflect heat into the room.

Do not block air inlets and outlets, including radiators, with furniture, drapes, or clothing.

Heating Ducts Inspect heating ducts annually for leaks. Repair them with a quality duct tape.

Cover heating ducts and water for steam pipes that pass through unheated areas, attics, crawl-spaces and basements with duct insulation or unfaced R-11 insulating batts or blankets. If ducts are used for air conditioning as well as heat, use faced insulation and place the vapor barrier to the outside to prevent condensation on the duct.

Care of Fireplaces and Chimneys

Fireplaces are expensive to install and sometimes even cause substantial heat losses. Even the best fireplaces are inefficient as home heating systems. Fireplaces are effective in cool weather when needed to "take the chill" off a room. Air ducting systems that draw from the room into the fireplace and return heated air to the room improve the heating efficiency. Air for combustion should be ducted in from the outside rather than drawn from the room.

If you use a fireplace, arrange for a chimney checkup annually. Hot gases that escape through cracks in a fireplace can harm you and may even cause a fire.

Check the chimney for loose bricks and mortar and the flue lining (the passage through which the air and gases travel) for cracks. Make repairs before using your fireplace.

Be sure that the damper at the top of the fireplace closes tightly; otherwise, warm air will escape when the fireplace is idle.

In summer, keep the damper closed to prevent sooty backdrafts and birds from entering the house.

Soot and creosote accumulations should be cleaned from the flue each year. Do this by pulling a weighted sack of straw up and down the flue. Seal the front of the fireplace before you begin to keep the mess contained.

Selecting or Altering A Heating Or Cooling System

When you replace or alter a heating system you will decide whether to use: (1) Solid, liquid, gaseous, electric, or solar fuels; (2) room units or central systems; (3) separate or combined heating and cooling systems; (4) air or water distribution systems; (5) a gravity or forced air distribution system; and (6) a manual or automatic control system.

Fuels

Fuel availability, costs and delivery charges differ from location to location. To decide on the right fuel, first find its heating value in therms or other energy units. Then determine the efficiency with which a heater can convert fuel to usable heat. Solid and liquid fuels require onsite storage. Electric and natural gas do not. Coal and wood probably will be more economical where they are readily available. Electricity is the cleanest fuel, followed by gas, oil, and solid fuels.

Room Units

Window air conditioners, underwindow heating/cooling units, space heaters, electrical and resistance heating devices are reasonably effective for heating or cooling single rooms. Unless equipped with blowers, large temperature variations may occur between the floor and the ceiling. Distribution of heat or cooling to adjacent rooms is poor.

Central Systems

Central systems heat or cool a whole house or apartment. They provide a uniform temperature distribution but cost much more to buy and install than room units. They require more energy to operate.

Central systems may employ gravity or forced air to distribute hot air, cold air, water, or steam. Although gravity systems are effective, they are difficult to design and the ducts take up a lot of space. Forced air systems generally provide more uniform heat distribution than do gravity systems. Hot water or steam systems require the services of a plumber and usually need more maintenance than other systems.

Heat Pumps

Heat pumps come both as package units that fit into the wall and as connected split systems. Split units are more expensive but more versatile than the smaller units, since the inside unit can be located anywhere in the house. Heat pumps both heat and cool on demand. They are more expensive than other systems, but where the climate is not severe operating costs may be one-third to one-half that of conventional electric heating. However, heat pumps may still cost more to operate than most nonelectric systems.

Control Systems

Most heating units can be either automatically controlled or operated manually. Cost increases with the degree of automation. However, poor manual control can result in overheating.

Distribution of Heating or Cooling

Central heating and cooling systems usually depend on air distribution. Air responds rapidly to thermostatic demand. An air system frequently costs less and is easy to install. Water or steam heating systems are generally more effective in conveying heat from the furnace and control comfort of individual rooms more evenly. A liquid system requires less space than do air ducts but responds slowly to the thermostat. Water heat can add difficult plumbing problems. Liquid systems offer superior efficiency in large buildings.

Facts Sheets In The Home Weatherization Series

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Agricultural Fact Sheet 2 - 3 - 7
United States Department of Agriculture
Office of Governmental and Public Affairs
Washington, D.C. 20250

August 1978

ENERGY WISDOM

water:

This can be conserved now - to save on the energy needed to pump it and/or heat it and at the same time learn to conserve one of our most valuable resources. Sixty gallons of water per day is used per person...on the average...according to U.S.D.A. Extension specialists, triple the amount since 1900. The following are a few suggestions for conserving water.

I. TOILETS - Use 5-7 gallons each flush, 45% of all water used indoors

1. Adjust the float level in the tank to reduce the amount of water needed.
2. Place a container such as a plastic quart bottle or jug filled with water in toilet tank (1 quart of water saved per flushing).
3. Check that water valve closes in tank after the toilet is flushed.
4. The toilet should not be used as a waste basket to dispose of cigarette butts, facial tissues, etc.
5. Don't flush as often.

II. BATHING - Use 30% of the water used indoors

1. Reduce the amount of water used while bathing, a full tub uses 36 gallons.
2. Take showers instead of bathing, it takes only 25 gallons of water.
3. Reduce length of shower and flow of water.
4. Try soaping up with the shower off, it saves 5-10 gallons each time.
5. Turn off the water while brushing your teeth. This can save a family 5-10 gallons a day.
6. The water should not be left running while shaving, fill the sink instead.
7. Teach children to turn water faucets off tightly after use.

III. DRINKING AND COOKING - Use 5% of all water used indoors

1. Keep a bottle of water in the refrigerator instead of letting the water run to get a cool drink.
2. Put water on the table for meals only if people really drink it.
3. Don't use the garbage disposal for items just as well thrown in the garbage can.
4. Don't use running water to quick-thaw foods, thaw them ahead of time under refrigeration.
5. Wash vegetables in pan of water, then use it for watering plants.
6. Use minimum of water for cooking vegetables. Save this water in a jar in the refrigerator to use in soups, sauces, etc. It is high in flavor, vitamins, and minerals.

COOPERATIVE EXTENSION SERVICE
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES, THE UNIVERSITY OF CONNECTICUT, STORRS
E.J. Kersting, Extension Service Director. Issued in furtherance of the Acts of Congress of May 8 and June 30, 1914.
The Cooperative Extension Service is an Equal Opportunity Agency.

IV. DISHWASHING - Uses 20% of all water used indoors (combined with clothes washing)

1. Wash only full loads in the dishwasher, as it uses 12-17 gallons each time.
2. Rinse dishes in a pan of water before putting them in the dishwasher.
3. Try not using the long cycle in the dishwasher. Experiment with shorter cycles and less detergent, you'll find dishes come out just as clean.
4. When hand-washing dishes, wash and rinse in containers of water, rather than under a running faucet.

V. CLOTHESWASHING

1. Wash only full loads in the washing machine, as it uses 27-50 gallons of water per cycle.
2. Use the variable load control if there is one on your washing machine.
3. Use the suds saver on your washing machine. You will save 16-19 gallons of water per load, plus detergent and energy.
4. Wash clothes in warm water, rince and cool.
5. Accumulate clothes for hand laundry to wash in batches, instead of one by one. Don't use running water.

VI. OUTDOORS

1. Water lawn in the early morning to avoid losses due to evaporation.
2. During the hot summer months, raise the blade on the lawn mower to about 1 1/2" in height. This provides shade for the roots and helps to reduce water loss.
3. Spend less time washing the car. A 20 minute car wash uses between 200 and 600 gallons of water.

VII. EQUIPMENT REPAIR AND REPLACEMENT

1. Replace any defective faucet washers to eliminate all drips.
2. Install aerators on all faucets.
3. Test regularly for toilet tank leaks. Put a small amount of food coloring in the tank, if it trickles into the bowl, there is a leak and repair is needed.
4. Replace the shower head with a flow restriction model.
5. Install pistol grip spring closed nozzles on all hoses outdoors.
6. Install automatic shutoffs on sprinklers.
7. Insulate hot water pipes to reduce the amount of water which must run to get hot water from the faucet.

Compiled by Patricia G. Stanton
References: California Water Resources Center
U.S.D.A.

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FACT SHEET

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 155A, Route 6
Bethel, Ct. 06801

UNITED STATES
DEPARTMENT
OF AGRICULTURE

ENERGY
CONSERVATION
IN THE RURAL HOME

Home Management Tips To Cut Heating and Cooling Costs

Heating and cooling your home may take as much as two-thirds of all the energy used there. This fact sheet suggests everyday things you can do to save energy and maintain comfort while heating and cooling your home.

Energy Efficient Use of Space

Don't heat or cool rooms not in use. Close off areas of the house that are not needed.

In summer, it is easier to keep the lower level of your house cool. If you have a choice, plan your living arrangements accordingly and cool only the rooms you need. The basement recreation room may also be used for sleeping during hot weather, reducing the need to cool bedrooms on upper levels.

Set Your Thermostat Conservatively

Begin the heating season by setting the thermostat no higher than 65° F. Turn it even lower for nighttime or while you are away for extended periods. During extremely cold weather, do not turn the thermostat so low that the heating system must labor to reach the 65° F temperature when you reset the thermostat. You may wish to install a time-clock thermostat which will automatically set back the temperature to your nighttime setting and reset it to the daytime temperature before you get up in the morning.

Turning the thermostat several degrees higher than desired when you arrive home or awaken in the morning does not speed the rate of heat delivery. It will, however, eventually run the temperature higher than necessary and waste fuel.

Avoid the temptation to turn the thermostat higher if you feel chilly. Instead, put on additional clothing for warmth or move to a sunny spot of the house.

If the house becomes warmer than necessary, set the thermostat down rather than opening windows. In fact, you may be more comfortable if you set the thermostat several degrees lower while you are working (active) and then set it higher when you relax in the evening.

In summer run the air conditioner only when and where you need cooling. Don't overcool. Set the thermostat no lower than 78° F.

A timer, to turn the air conditioner on in advance of your arrival home, will let you come home to a cool house, yet save running the air conditioning all day.

Ventilate Correctly

Before air conditioning was invented, people opened up the house at night to let it fill with cool air. In the morning when the sun began to heat up things, the house was closed until evening. This practice may have some application in your home today.

During mild weather, use a fan instead of an air conditioner. A window fan uses only a small fraction of the energy of air conditioning units. You probably can use your window air conditioning unit to circulate air and still be comfortable without using the cooling unit.

When your window air conditioner is running, close the registers from your heating system. This prevents cold air from escaping into the ductwork.

Use exhaust fans in kitchen and bathroom sparingly during cold weather. They remove the warm air from the house. During hot weather, limit the use of the exhaust fan while using the air conditioning. When the air conditioning is not being used after the temperature has dropped in the evening, the exhaust fans can be used effectively to help pull outside cooler air into the house. Remember to open a window on the opposite side of the house.

In summer, higher temperatures are easier to tolerate if the humidity level is lower than 60 percent. You may find that the use of a dehumidifier improves the comfort level and requires less energy than running the air conditioning system. Remember to keep doors and windows closed when using the dehumidifier or air conditioner. Conversely, increasing the humidity level during very cold weather will improve the comfort level.

Watch How You Use Doors

Needless opening of outside doors during cold weather lets lots of heat out and equal amounts of cold air in.

Remind all members of the family to close the door quickly as they enter or exist. Keep in-and-out trips to a minimum.

Be sure doors are closed properly. Doors left ajar drain heat rapidly.

A simple way to keep drafts from around windows and from under doors is to make "draft chasers" to place against the closed door or window. First use a tightly woven fabric to make a tubular casing 2 to 3 inches in diameter the width of the door. Then fill it with sand and you have a "draft chaser."

If you have an attached garage, keep the doors closed. Always close the big door before opening the door into the house.

Cover Your Windows at Times

Practical benefits of keeping windows covered in cold weather are that you're more comfortable because body heat is quickly lost to cold uncovered windows; you're also curbing a major source of heat loss in most houses.

If you cover your windows with roller shades, they should be installed within the window frame, close to the glass, and fitted snuggly on the sides.

Draperies are more effective when they are installed with a close-fitting cornice over the drapery or are closely fitted to the ceiling to prevent air flow over the window. Lined draperies or draperies made of a closely woven fabric are the most effective in reducing heat loss from your body when you are near a cold window.

In winter, shutters, shades, or draperies can be used effectively to reduce heat loss on the cold side of the house. On the sunny side, windows should be uncovered to let in the most solar heat.

During the summer, keep out solar heat by covering the windows when the sun strikes. Especially shade the east windows. When the sun shines strongly on them each morning, it heats the house. Next cover west windows that are exposed to the afternoon sun. Even though the summer sun may not enter south windows directly, reflected heat may be a a problem on the south of the house.

Don't Forget Floors

Carpets are warmer to the touch and offer more insulation than wood, slate, or resilient floor coverings. The thicker the carpeting and padding, the greater the insulating quality. Carpet with fuzzy yarns that trap air have greater insulating qualities than carpet with smooth yarns.

In carpeted houses you feel warmer because less of your body heat is radiated to the floor. You can turn the thermostat lower and still be comfortable. For every degree you lower the thermostat, you generally save 2 or 3 percent of your heating bill.

However, if you choose between insulating under the floor of an unheated area or carpeting, remember that the insulation will be the most effective.

Placing Furniture

Place furniture far enough away from radiators, registers, and cold air return vents to permit free circulation of heated or cooled air. You will be more comfortable during extremely cold weather if you sit away from windows and outside walls.

Chairs with closed arms and backs or closed upholstered chairs will help hold body heat so you will feel warmer.

Dress For Comfort

If you are chilly when your themostat is set at 65° F in the winter, wear additional clothing. Several layers of clothing will be more comfortable than restrictive heavy garments.

During summer heat, absorbent cotton, cotton blends, and linens provide the most comfort. Wool or woolen blends are best for cold weather wear.

Keep Extra Blankets

Two lightweight blankets that trap the air between them keep you warmer and more comfortable than one heavy blanket.

Some people may prefer an electric blanket and sleep in a cold room. But they should keep regular blankets on hand in case of electrical power outages.

House Care and Maintenance

Periodically, clean radiators or heating/cooling registers and ductwork.

Filters in the hot air heating/cooling system should be cleaned or replaced regularly to keep the air moving freely. Check to see that the consenser unit of the central air conditioning unit, located outside the house, does not become clogged with grass and leaves.

Clean windows to allow the maximum radiant heat to enter in cold weather. Shade them during hot periods.

Agriculture Fact Sheet 2-3-9
United States Department of Agriculture
Office of Governmental and Public Affairs
Washington, D.C. 20250

November 1978

III. Behavioral Objectives

The final category of this conservation unit is that of behavioral objectives. It should be noted that weatherization and proper utilities use, but not insulation, will be emphasized. Insulation has its own unit within this document. Much of this material is in depth thus middle and jr. high schools ought to utilize only that amount relevant to their needs. On the other hand, senior high school usage should involve the total package of the suggested objectives.

Since tools and equipment have been listed in a different area of this document, only those materials/processes not otherwise covered will be presented here. Thus the student, upon completion of this unit, will be able to:

A. Do original research - all pertinent information, i.e.,
  1. If building centered - the student will be able to find and interpret:
    a. Zoning regulations
    b. Building codes - local, regional, state, (national if required)
    c. Other ordinances/codes

    d. Gather all pertinent data about the involved family or business and its life-style, socio/ecol., MIC, health, emotional, philosophy, ecology, etc.

    e. Note: that this research would concern itself with health standards, external house appearances and property compatibility.

  2. If project centered - gather all pertinent data reflecting on the current project, i.e., of a drawing and design nature - - - all of the above, plus:

    a. Public domain

    b. State of the arts - status quo

    c. Patent exclusions

    d. Royalties

B. The student will be able to analyze gathered data of original research - - -

  1. If building centered - the student will be able to evaluate and:

    a. Determine that the property/land will not be devalued, defaced, or otherwise damaged, but will enhance the community in appearance, activity, and income.

b. Determine that the family/business and its life-style will positively merge with the affected community, the land, and their combined well being.

c. Determine that the structure of this residence refurbished externally and internally (new windors, siding, etc.) will harmoniously resolve the family/business, the land, and the community into positive action.

2. If project centered - the student will be able to correctly analyze and:

   a. Determine that the original hypothesis and the ensuing results are, in fact, valid and proven.

   b. Determine that no patent infringement exists

   c. Determine that public will benefit therefrom

   d. Determine that client will not be harmed, physically, emotionally, or legally.

   e. Determine that ecology will not be damaged

   f. Determine that current state of art is being enhanced by the product

C. The student will be able to arrive at conclusions as objectively as possible - - -

1. If building centered, the student will be able to conclude that:
    a. Conservation is a valid, essential, and viable alternative
    b. The necessary permits, paper work, and signatures, etc., legally activate the renovation
    c. The communications, supplies, deliveries, labor, capital, travel, weather conditions, local inspectors, etc., are immediately available
    d. A fundamental command of above processes is essential via teacher/student evaluation
2. If project centered - the student will be able to conclude that:
    a. Conservation both as a concept and implemented as a reality is valid, essential, and viable
    b. Legally all systems are go

    c. Progress begins with the first proper step into critical development and evaluation
    d. The scientific method is functional and desirable

D. The student will be able to completely and correctly design and make all working drawings and details of whatever will be required for the partial or complete implementation of the total conservation project.

1. Buildings
    a. Plans
    b. Elevations
    c. Details
    d. Tracings
    e. Reproductions
    f. Specification listing
2. Project/system (s) only
    a. Normal orthographic drawings
    b. Working drawings fully dimensioned and notated
    c. Specification/bill of material listing
    d. Pictorial rendition of project (whatever)

E. The student will be able to properly construct and utilize data gathering devices, i.e., efficiency of conservation, re:

1. Graphs - bar, line, circle, pictogram, pictorial, i.e.,
   a. Learn how to collect targeted data properly
   b. Learn to design and construct the most effective graph for the job
   c. Learn how to depict the assessed data correctly
   d. Learn how to interpret graph information - functionally
   e. Learn how to properly apply this information.
2. Charts - time, rectilinear, bars, flow, operations and organization
   a. Learn how to gather identified raw material correctly
   b. Learn how to design the most functional chart for the application
   c. Learn how to position the clarified material properly

        - d. Learn how to evaluate any chart information objectively
        - e. Learn how to correctly apply this information
    3. Diagrams - motion, process, analysis, operative, identification
        - a. Same as above graphs and charts
        - b. " " "
        - c. " " "
        - d. " " "
        - e. " " "
    4. Tables for research and documentation re: their correct use and application:
        - a. ASHRAE conservation materials
        - b. Weather/meteorological
        - c. HUD energy materials listing
        - d. ANSI materials testing results
        - e. AIA weatherization tables
        - f. Etc.

F. The student will now be able to knowledgeably

1. Research
2. Analyze

3. Select

4. Maintain

5. Repair

6. Evaluate system effectiveness of each of the following conservation devices:

   a. Working check list for functional weatherization implementation

   b. General/specific weatherization applications - materials, processes, equipment

   c. Windors* - thermopane type windows, conventional storm sash, triple track double/screen, plexiglass - polyvinyl sheeting as well as combination storm doors, insulated-core metal exterior doors, solid core, foam core wood, etc., doors

   d. Sealants-caulking, silicones, butyls, mastic, putty, etc., and paints, sealers

   e. Weatherstripping - Kapoc, foam, metal: re headers, jambs sills/saddles, tapes

   f. Moisture vapor barrier - polyvinal, polyethylene 4 mil upwards & sealants, paints

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* Approved architectural abbreviation for windows and doors

g. Window blinds, shutters, pop-ins, shades, etc., climate control devices

h. Hot water controlled heating and use

i. Home management tip list for conservation improvement - ongoing

IV. INSULATION, ENHANCER OF SOLAR/ALTERNATIVE ENERGY

I. Introduction

Without insulation no realistic climate control could exist. It enhances energy induced warmth or coolness, whatever the preference. Thus, comfort can be insured in both winter and summer by proper use of insulation. However, buildings are not the only things improved by the presence of insulation. It is also found in tools, machines, automobiles, airplanes, ships, boats, and many other devices. In all of these, temperature control is the objective. The more insulation of the right kind used the less energy will be required to influence temperature modification.

Essentially, there are seven basic forms of insulation. These are:

A. Reflective - usually aluminum foil reinforced in single & multiple money-combed-fold layers - - - no longer a dominant article in the marketplace, although utilized for specialized requirements & still around in original installations.

B. Blanket - usually available in 50 foot continuous roll of varying thicknesses and widths, i.e., for 2 x 4 & 2 x 6 cavities & for 16 & 24 inch centers. This is available with & without H_2O proof backing and tabs. It usually is composed of glass wool, rock/slag wool cellulose fibers, kapok, & vegetable fibers.

C. Batts - similar to blanket composition but somewhat more inflexible and 4 & 8 feet in length.

D. Loose fill - available in bag form - of differing sizes, usually advertised in cubage form and composed of a wide variety of materials, i.e., plastics, minerals, cellulose, kapok, cotton, and vegetable.

E. Rigid foam boards or sheets in varying sizes and thicknesses, from 16 o.c. to 4 & 8 footers with several thicknesses usually 1 to 3 inches with and without foil skins, usually polystyrene and polyurethane.

F. Injected foam, i.e., from semi-liquid form to foam expansion form. This is applied wet with gas activators. Curing inevitably causes shrinkage which research[1] indicates will continue until it has shrivelled up. It also has the potential for health hazards not found in the others - - - now illegal in U.S.A. (1982)

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[1] University of Connecticut insulation & Solar Research Dept. of Engineering

G. Hard board insulation of wood or fiber is the last. It is really too thin & dense to be as effective as any of the A to F previously mentioned.

II. Implementation

Following are a series of energy sheets depicting insulation utilization - - - .

79-40

6

energy facts

How to insulate your home

save Energy save Dollars

The University of Connecticut
Cooperative Extension Service,
Storrs, Ct. 06268

Thermal insulation is a material installed in a structure to reduce heat transfer. Because it forms a protective blanket around the living area of a home, insulation is needed around all areas heated in winter and cooled in summer.

Adding insulation to an existing structure is sometimes difficult, but the time to start is now. Delay means continuing high costs for heating and cooling.

The illustration at the bottom of the page shows where a home should be insulated.

A homeowner planning to install insulation should be familiar with the effects of excess moisture in a home and should take steps to alleviate them. Moisture breaks down insulation. Vapor barriers and ventilation restrict and reduce excess moisture; they go hand-in-hand with properly installed insulation.

Vapor Barriers

A vapor barrier restricts the passage of moisture through walls and ceilings. A barrier is necessary to protect a structure against mildew, rot, peeling paint, and a breakdown of insulation. Commonly used vapor barrier materials are kraft paper, aluminum foil, and plastic sheeting.

A vapor barrier is always placed next to the living area or against the warm side of a wall, ceiling, or floor. In order to be most effective, the barrier must be continuous and must be in contact with the warm side of the area being insulated.

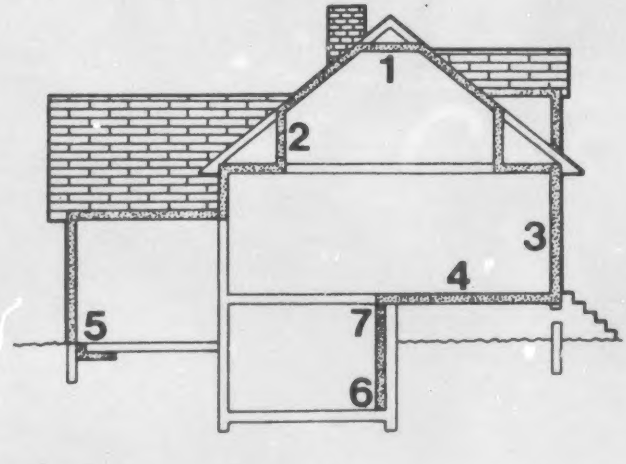
DO NOT INSTALL A VAPOR BARRIER BETWEEN LAYERS OF INSULATION.

Insulation "R" Value

The following chart shows the minimum R-Values recommended for homes in the northern part of the United States. Insulation can be combined to achieve a desired R-Value. For example, rolls of R-19 and R-11 can be used together to reach a total R-Value of 30. If two

Where to Insulate a Home

1. Ceilings with cold spaces above
2. Rafters and "knee" walls of a finished attic
3. Exterior walls; walls between heated and unheated spaces; dormer walls
4. Floors over outside or unheated spaces
5. Perimeter of a concrete floor slab close to grade level
6. Walls of finished or heated basement
7. Top of foundation or basement wall



layers are needed, strip the vapor barrier from the second layer and place it at right angles to the first. Insulation without vapor barriers is available.

Insulation	Where Used
R-11	walls, including basement; crawl spaces; heating ducts
R-13	floors over unheated spaces; walls in very cold climates; heating ducts
R-19	ceilings; floors in very cold climates
R-30	ceilings (if walls are poorly insulated)

Quantity of Material Needed

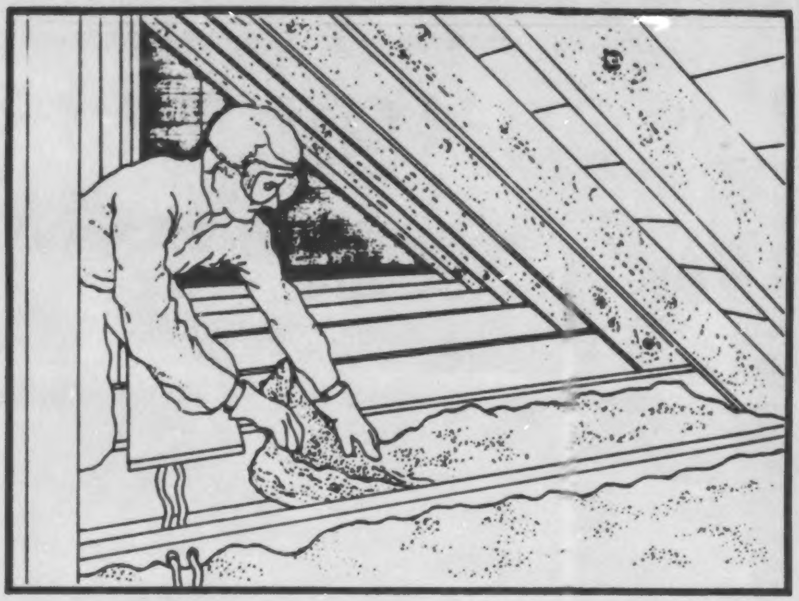
To determine the amount of material needed, multiply in feet the length times the width of the area to be insulated. Also determine the width (15'' or 23'') if batts or blankets are to be used.

Labels on insulation wrappers indicate the number of square feet one bundle or bag will cover. Divide that number into the total square feet of the area you plan to insulate to determine how many bundles or bags you will need.

Attics and Ceilings

Unfinished attic floors can be insulated with batt, blanket or loose-fill material. Before you begin insulating, check for roof leaks and make necessary repairs. Also, caulk all openings where ducts, pipes, or wires penetrate the floor.

NOTE: A BREATHING MASK SHOULD ALSO BE WORN!

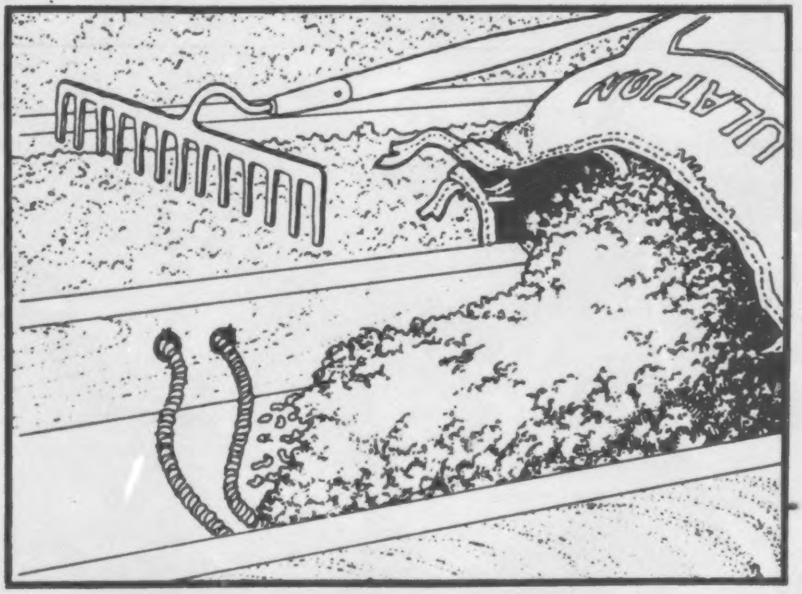


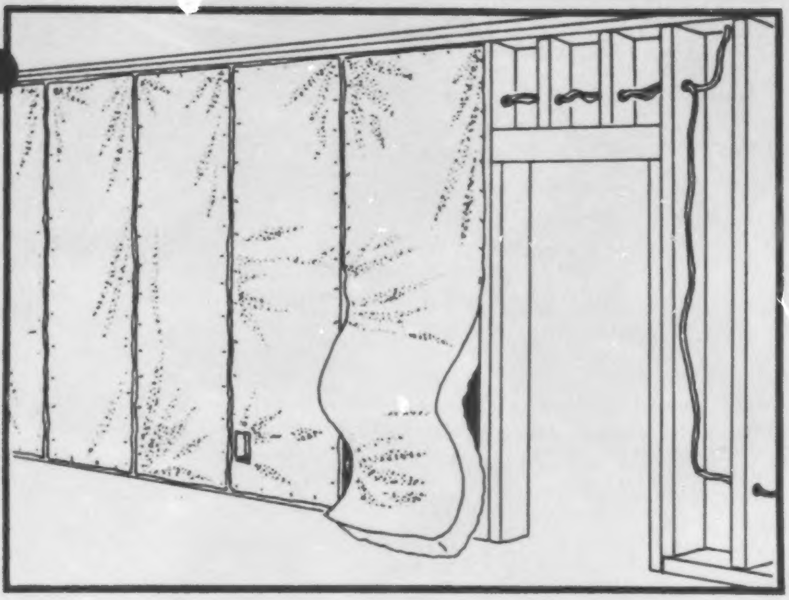
Press—but do not crush—the insulation between the joists or trusses. Begin at the outer edge and work toward the center where it is easier to cut and fit. Cover the top plate, but leave a 3'' ventilation path around the attic perimeter. Don't leave gaps; butt the material at trusses or cross bracing.

Use unfaced material to insulate the space between the chimney and wood framing.

Insulate heating ducts—first making sure seams are sealed—and water pipes. If ducts are used for heating and air conditioning, keep the vapor barrier on the outside of the insulation, otherwise a barrier is unnecessary.

If using loose-fill, maintain a consistent density. Do not crush the material: use a rake or board to level it. Use a baffle—a piece of batt insulation works well—to keep insulation away from eave vents and ven-





tilation path.

Under Floors

Insulation is needed under floors if the space below is unheated. Faced batt insulation is the easiest material to work with in this situation. The vapor barrier should face up; a ventilation space should be left between the vapor barrier and the floor.

Keep the insulation in place by lacing wire between the bottom of joists or staple short sections of chicken wire across the joists and slide the insulation on top of the wire. Don't leave gaps!

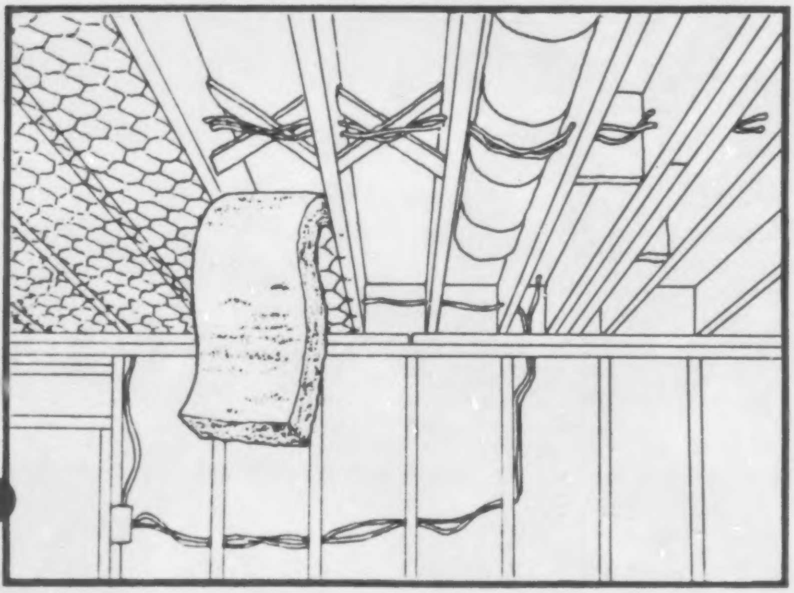
Cover ducts and water pipes as described in the section on attic and ceiling insulation.

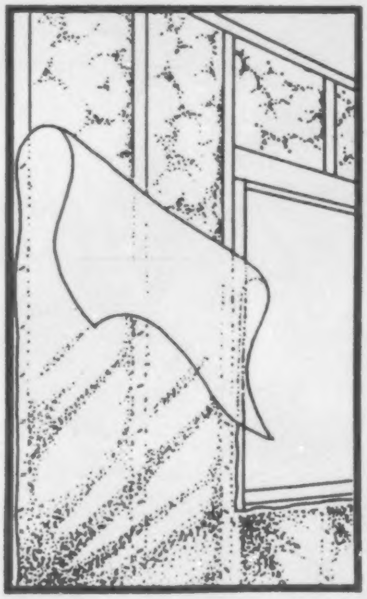
Open Frame Walls

Batts or blankets are the usual choices of the do-it-yourselfer who wants to insulate open sidewalls. Cut the blankets slightly longer than the height of the wall so they can be tucked at the top and bottom. Press the insulation between the studs. The insulating material should touch the siding; the vapor barrier should face the heated side of the wall. Working from the top, staple the binding of the insulation to the face of the studs at 8'' intervals.

Work insulation behind outlet boxes, ducts, and pipes. Use small pieces to get around and behind window and door frames, sills, and header joists. These areas should then be covered with a vapor barrier.

If unfaced blankets are used, cover the material after installation with 4-mil plastic sheeting. Cover the full wall and staple at the top, bottom, and along the studs. Cut out openings for windows, doors, and outlet boxes after the vapor barrier is secured.



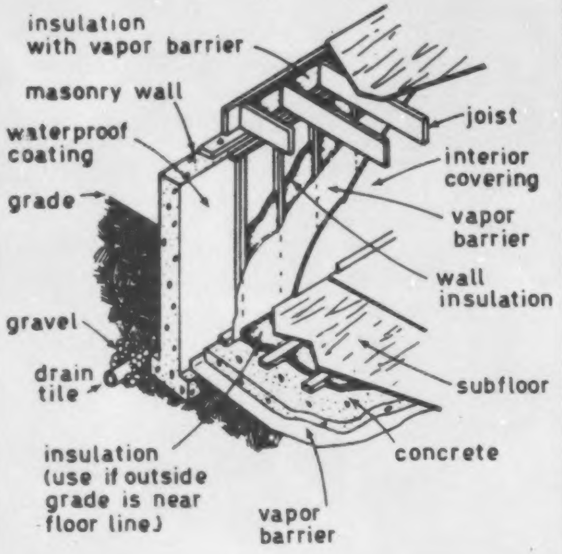


Masonry walls can be insulated in much the same way as frame walls. Nail treated furring strips 16'' or 24'' on center to the wall and proceed as directed in the section on open frame walls.

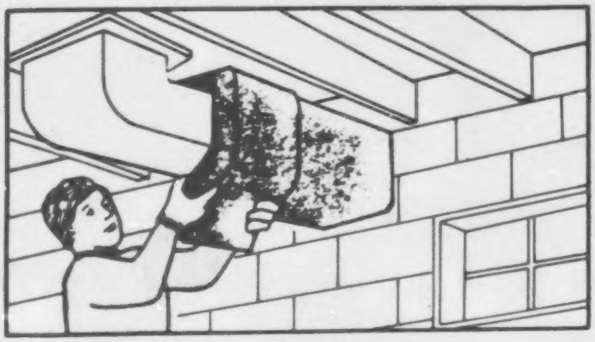
basements

Insulated floors and basements keep more comfortable and save heat. Insulate basement walls, whether finished or not, at least two feet below the outside ground level. Houses with masonry walls can be insulated like basements with furring strips and insulation batts. Be sure to insulate the joist area between the basement wall and the first floor. With new construction, insist on the installation of a vapor barrier under the concrete floor. Never omit the external drain tile below the grade.

MASONRY WALL or BASEMENT INSULATION



Insulate ducts and hot water pipes passing through unheated areas. Wrap the water heater with a mineral wool blanket to save even more.



Vapor Barriers

In areas where January temperatures average 35°F or lower, the first signs of spring may include dark stains and peeling paint on house siding caused by cold weather condensation.

A typical family of four converts 3 gallons of water into water vapor each day. Unless excess water vapor is removed during the heating season, by ventilation usually, it will increase the humidity and condense on cold surfaces such as window glass. More serious, however, it can move through walls or the ceiling to some cold surface, often condensing as ice or frost. During warm periods the frost melts, causing high heat losses, staining, paint blistering, and decay.

Insulation can make moisture problems worse. In fact, the more efficient the insulation is in retarding heat flow, the colder the outer surfaces become and the greater the potential for moisture condensation.

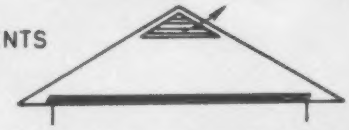
A vapor barrier of aluminum foil, polyethylene film, or kraft and asphalt building paper minimizes moisture movement into the structure. A separate polyethylene film vapor barrier is recommended in addition to any vapor barrier that may be attached to one side of roll blankets or batts. Place the vapor barrier as close as possible to the **inside** or **warm** side of the insulation.

Ventilation

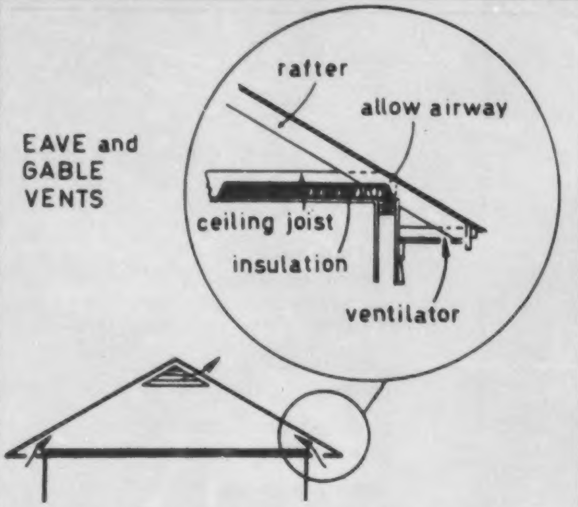
Attics should be ventilated to remove any water vapor that gets past the vapor barrier. If signs of condensation are noted after one heating season add more attic vents. Outside walls should allow water vapor to escape.

Vapor barriers may not be as essential in ceilings and floors of most rooms where there is good ventilation above and below. The high humidities found in bathrooms, kitchens, and laundries may require a vapor barrier. Enamel oil base paints and vinyl wallpaper are often used to decorate these rooms and some can substitute as vapor barriers.

GABLE VENTS



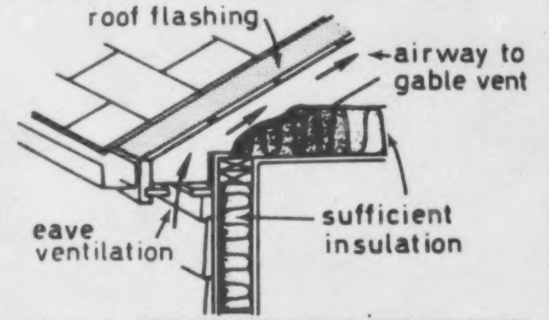
Attic with gable vents at each end. Total vent opening should be 1 square foot for every 300 feet of ceiling area. Double the vent area if screen and louvers are installed on the vents. If the ceiling has no vapor barrier more vent area may be needed.



Attic with eave opening and gable vent. Allow 1 square foot of eave area and 1 square foot gable vent area for each 900 square feet of ceiling area, if the ceiling has a good vapor barrier.

Ice Dams

In areas with heavy snowfall, ice dams can form to trap water and cause it to leak into the house. Poorly insulated houses without proper ventilation lose enough heat to melt snow on the roof. The water flows down the roof and refreezes on the cold overhang, forming an ice dam that backs up water. Adequate attic insulation with gable and eave vents will keep the attic cold enough to eliminate most ice dam problems.



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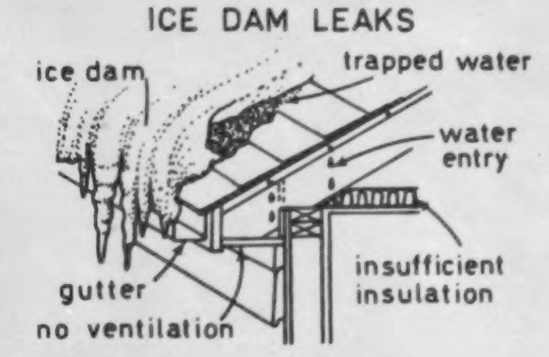

Poor attic ventilation and insufficient insulation can cause ice dams and water damage.

Selected References

Making the Most of your Energy Dollars in Home Heating and Cooling. 17 pages. Helps you calculate the best combination of insulation for your climate and fuel prices. Describes what to look for when buying insulation. Installation directions not included. Sold by Consumer Information Center, Pueblo, Colorado 81009, 70¢.

In the Bank...or Up the Chimney. 70 pages. Instructions on how to weatherstrip and insulate existing houses. Includes a section to help you calculate cost and savings factors of energy conservation improvements. Sold by Consumer Information Center, Pueblo, Colorado 81009, $1.70.

Save Energy—Save Dollars. 95 pages. Includes many tips on how to cut energy use around the home. Buy this Cornell Info. Bull. 125 from the Mail Room, Cornell University, Ithaca, NY 14853, $1.50.

Condensation Problems in Your House: Prevention and Solution. 39 pages. Why condensation occurs in houses and how to stop it. How to install vapor barriers and provide attic vents in frame houses. This USDA Agr. Info. Bull. No 373 is sold by the Consumer Information Center, Pueblo, Colorado 81009, 85¢.

How to Save Money by Insulating Your Home. An excellent pocket guide on insulation — how and where to install it. Order from National Mineral Wool Association, 382 Springfield Av., Summit, NJ 07901, 30¢.

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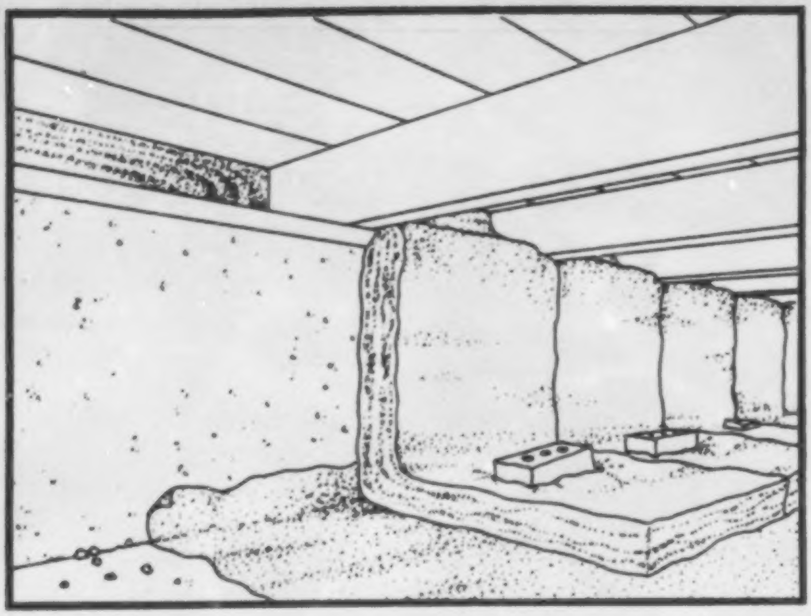

Crawl Spaces

Follow the directions for installing insulation under floors for the overhead part of the crawl space.

If joists run parallel with the wall, cut the insulation to cover the height of the wall and 2' of the floor. Use nailing strips to attach the insulation to the band joist.

If joists run at right angles to the wall, nail the insulation to the sill plate. Fill the area between the sill plate and the subfloor with short pieces of insulation.

After the insulation is in place, run a sheet of 6-mil plastic across the ground or floor. Tuck it under the insulation so it touches the wall. Tape the joints or lap them.

As a last step, weight the insulation around the perimeter of the crawl space with 2x4 lumber or rocks. Patch any tears or holes punched in the vapor barrier during installation.

Safety and Comfort Tips

Insulating material is usually dusty and itchy and may cause temporary skin irritation; often it is installed in cramped and sometimes hazardous locations. Protect yourself and your home while installing insulation by following these safety tips:

- Wear old, loose clothing and wash it separately when the job is done.
- Handle insulation with rubber gloves and wear a breathing mask and goggles.
- Wear a "hard" hat to protect your head from roofing nails and obstructions.
- Tape foam rubber around your knees if insulating an attic or crawl space. It will lessen discomfort.
- Provide good lighting: use a "trouble" or spotlight and have a long extension cord handy.
- Use temporary flooring while insulating an unfinished attic. The ceiling below will not support an adult's weight.
- Don't smoke while installing insulation.
- Shower thoroughly after handling insulation material.

NOTE: These fact sheets are adapted from a series published by the New York State College of Agriculture and Life Sciences and the New York State College of Human Ecology, Cornell University, Ithaca, N.Y.

For more information ask one of the following offices:

Fairfield County 748-8756
Route 6 — Stony Hill, Bethel 06801

Hartford County 232-4972
1280 Asylum Avenue, Carriage House, Hartford 06105
or 19 High Street, Bristol 06010 584-2387

Litchfield County 567-0298
Agricultural Center, Litchfield 06759

Middlesex County 345-2695
Extension Center, Haddam 06438

New Haven County 789-7136
649 Howard Avenue, New Haven 06519

Tolland County 871-1604
24 Hyde Avenue, Vernon 06066

New London County 886-2167
562 New London Turnpike 06360

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Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

Following are currently available insulations and their lab analyses. This information is most difficult to obtain and has thus been included in this unit. It is derived from The American Society for Testing and Materials via The Cooperative Extension Energy Agent, Fairfield County Agricultural Center, RD #2, Box 165A, Route 6, Bethel, CT 06801 - courtesy Alice E. Holmes.

Alice E. Holmes
Cooperative Extension Energy Agent
Fairfield County Agricultural Center
RD #2, Box 165A, Route 6
Bethel, Ct. 06801

Table 3.3
FIBERGLASS

Material Property	Value	Test Method
Density	0.6-1.0 lb/ft^3	
Thermal Conductivity (k factor)	varies with density	
Thermal Resistance (R value) per 1" of thickness* at 75F	3.16 hft^{2}F/Btu (batt) 2.2 hft^{2}F/Btu (loose-fill)	ASTM C518, C653
Water Vapor Permeability	>100 perm-in	
Water Absorption	<1% by weight	ASTM C553-70
Capillarity	none	
Fire Resistance	non-combustible	ASTM E136
Flame Spread	15-20	ASTM E84
Fuel Contributed	5-15	
Smoke Developed	0-20	
Toxicity	Some toxic fumes could develop due to combustion of binder.	
Effect of Age		
a) Dimensional Stability	none (batt) settling (loose-fill)	
b) Thermal Performance	none	
c) Fire Resistance	none	
Degradation Due To		
Temperature	none below 180°F	
Cycling	none	
Animal	none	
Moisture	none	
Fungal/Bacterial	does not promote growth	
Weathering	none	
Corrosiveness	non-corrosive	Federal HH-I-5512
Oder	none	ASTM C553 - Sec. P

Derived from R19 and R11 products for 6 and 3.5" thickness respectively.

Table 3.6

ROCK AND SLAG WOOL

Material Property	Value	Test Method
Density	1.5-2.5 lbs/ft^3	
Thermal Conductivity (k factor) at 75F	0.31-0.27 Btu-in/ft^{2}hr°F (batts) 0.34 Btu-in/ft^{2}hr°F (loose fill)	ASTM C177
Thermal Resistance (R value) per 1" of thickness at 75F	3.2-3.7 hft^{2}F/Btu (batts) 2.9 hft^{2}F/Btu (loose fill)	ASTM C177
Water Vapor Permeability	> 100 perm-in	
Water Absorption	2% by weight	
Capillarity	none	
Fire Resistance	non-combustible	ASTM E136
Flame Spread	15	ASTM E84
Fuel Contributed	0	
Smoke Developed	0	
Toxicity	none	
Effect of Age		
a) Dimensional Stability	none (batt) settling (loose-fill)	
b) Thermal Performance	none	
c) Fire Resistance	none	
Degradation Due To		
Temperature	none	
Cycling	none	
Animal	none	
Moisture	transient	
Fungal/Bacterial	does not support growth	
Weathering	none	
Corrosiveness	none	
Odor	none	

Table 3.7
CELLULOSE

Material Property	Value	Test Method
Density	2.2-3.0 lb/ft^3	
Thermal Conductivity (k factor) at 75F	0.27 to 0.31 Btu-in/ft^{2}hr°F	ASTM C177, C518
Thermal Resistance (R value) per 1" of thickness at 75F	3.7 to 3.2 hft^{2}F/Btu	
Water Vapor Permeability	high	
Water Absorption	5 - 20% by weight	ASTM C739
Capillarity	not known	
Fire Resistance	Combustible	E-136
Flame Spread	15-40	ASTM E84
Fuel Contributed	0-40	
Smoke Developed	0-45	
Toxicity	develops CO when burned	
Effect of Age		
a) Dimensional Stability	settles 0-20%	
b) Thermal Performance	not known	
c) Fire Resistance	inconsistent information	
Degradation Due To		
Temperature	none	
Cycling	not known	
Animal	not known	
Moisture	not severe	
Fungal/Bacterial	may support growth	
Weathering	not known	
Corrosiveness	may corrode steel, aluminum, copper	ASTM C739
Odor	none	ASTM C739

Table 3.8

EXPANDED POLYSTYRENE FOAM

Material Property	Value	Test Methc
Density	0.8 to 2.0 lb/ft^3	
Thermal Conductivity (k factor)	0.20 Btu-in/ft^{2}hr°F (extruded) 0.23–0.26 Btu-in/ft^{2}hr°F (molded)	ASTM C177, C
Thermal Resistance (R value) per 1" of thickness at 75F	5 hft^{2}F/Btu (extruded) 3.85 to 4.35 hft^{2}F/Btu (molded)	
Water Vapor Permeability	0.6 perm-in extruded 1.2 to 3.0 perm-in molded	ASTM D2842-6 ASTM C355
Water Absorption	<0.7% by volume extruded <0.02% by volume extruded <4% by volume molded <2% by volume molded	ASTM D2842-69 ASTM C272 ASTM D2842-59 ASTM C272
Capillarity	none	
Fire Resistance	combustible	ASTM E136
Flame Spread	5–25	ASTM E84
Fuel Contributed	5–80	
Smoke Developed	10–400	
Toxicity	develops carbon monoxide when burned	
Effect of Age		
a) Dimensional Stability	none	
b) Thermal Performance	k increases to 0.20 after 5 years extruded none molded	
c) Fire Resistance	none	
Degradation Due To		
Temperature	above 165°F	
Cycling	none	
Animal	none	
Moisture	none	
Fungal/Bacterial	does not support	
Weathering	direct exposure to UV light degrades polystyrene	
Corrosiveness	none	
Odor	none	

Table 3.9

POLYURETHANE/POLYISOCYANURATE FOAMS

Material Property	Value	Test Method
Density	2.0 lb/ft^3	
Closed Cell Content	90%	ASTM C591-69
Thermal Conductivity (k factor)	0.16-0.17 Btu-in/ft^{2}hr°F (aged & unfaced or spray applied 0.13-0.14 Btu-in/ft^{2}hr°F (impermeable skin faced)	ASTM C177, C518
Thermal Resistance (R value) per 1" of thickness at 75F	6.2-5.8 hft^2°F/Btu (aged unfaced or spray applied) 7.7-7.1 hft^2°F/Btu (impermeable skin faced)	
Water Vapor Permeability	2 to 3 perm-in	
Water Absorption	Negligible	
Capillarity	none	
Fire Resistance	combustible	ASTM E136
Flame Spread	30-50 polyurethane 25 polyisocyanurate	ASTM E84
Fuel Contributed	10-25 polyurethane 5 polyisocyanurate	
Smoke Developed	155-500 polyurethane 55-200 polyisocyanurate	
Toxicity	produces CO when burned	
Effect of Age		
a) Dimensional Stability	0-12% change	ASTM D-2126
b) Thermal Performance	0.11 new 0.17 aged 300 days	
c) Fire Resistance	none	
Degradation Due To		
Temperature	above 250°F	
Cycling	not known	
Animal	none	
Moisture	limited information available	
Fungal/Bacterial	does not promote growth	
Weathering	none	
Corrosiveness	none	
Odor	none	

Table 3.10

UREA-FORMALDEHYDE AND UREA-BASED FOAMS

Material Property	Value*	Test Method
Density	Wet - Approximately 2.5 lb/ft^3 Dry - 0.6 to 0.9 lb/ft^3	Weigh a foam-filled plas bag of known volume.
Closed Cell Content	0.7% - 80%	
Thermal Conductivity (k factor)	0.24 Btu-in/hrft^{2}F	ASTM C177-76 Mean temperature 75F
Thermal Resistance (R value) per 1" of thickness at 75F	4.2 hft^{2}F/Btu	
Water Vapor Permeability	4.5 to 100 perm-in @ 50% rh 73F	ASTM-C355
Water Absorption	32% by weight (0.35% volume) 95%rh 18% by weight (0.27% volume) 60%rh 68F 180-3800% by weight (2-42% volume) immersion	
Capillarity	slight	
Fire Resistance	combustible	ASTM E-136
Flame Spread	0-25	ASTM E84
Fuel Contributed	0-30	
Smoke Developed	0-10	
Toxicity	No more toxic than fumes from burning wood.	
Effect of Age		
a) Dimensional Stability	1 to 4% shrinkage in 28 days due to curing. 4.6 to 10% shrinkage @ 100F 100% rh for 1 week 30 to 45% shrinkage @ 158F 90 to 100% rh - 10 days	ASTM D2126 proc C ASTM D2126-66
b) Thermal Performance	No change	
c) Fire Resistance		
Degradation Due To		
Temperature	Decomposes at 415F	
Cycling	No damage after 25 freeze-thaw cycles.	
Animal	Not a feed for vermin.	
Moisture	Not established	
Fungal/Bacterial	Does not support growth.	ASTM G21-70 (1975)
Weathering		
Corrosiveness		
Odor	May exude formaldehyde until cured	

*taken from Reference 21.

Table 3.11

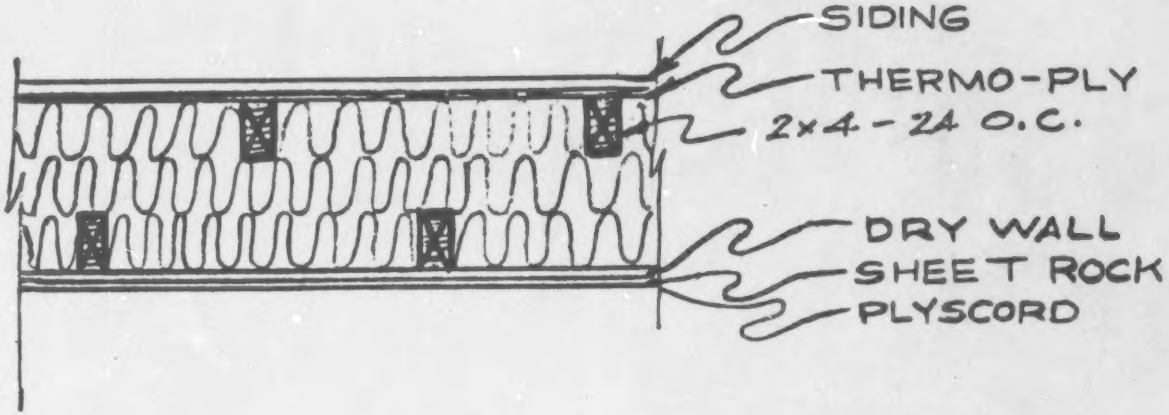
PERLITE

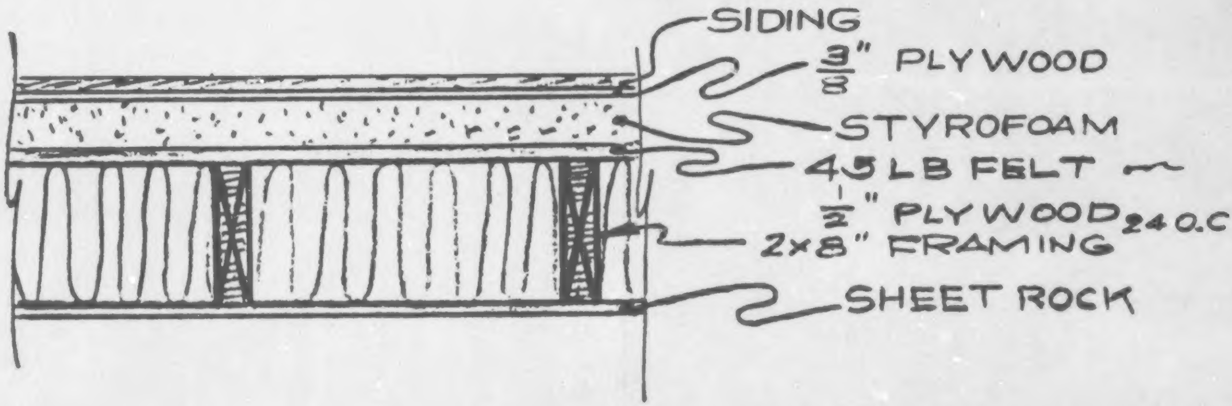
Material Property	Value		Test Method
	Loose-Fill	Perlite Concrete	
Density	2-11 lb/ft^3	20-40 lb/ft^3	
K_{app} at 75F	0.27-0.40 Btu-in/ft^{2}hr°F	0.50-0.93 Btu-in/ft^{2}hr°F	ASTM C-177
Thermal Resistance (R value) per 1" thickness at 75F	3.7-2.5 hft^{2}F/Btu	2.0-1.08 hft^{2}F/Btu	
Water Vapor Permeability	high	high	
Water Absorption	low		
Capillarity			
Fire Resistance	non-combustible	non-combustible	ASTM E136
Flame Spread	0	0	ASTM E84
Fuel Contributed	0	0	
Smoke Developed	0	0	
Toxicity	not toxic	not toxic	
Effect of Age			
a) Dimensional Stability	none	none	
b) Thermal Performance	none	none	
c) Fire Resistance	none	none	
Degradation Due To			
Temperature	none under 1200°F	none under 500°F	
Cycling	none	none	
Animal	none	none	
Moisture	none	none	
Fungal/Bacterial	does not promote growth	does not promote growth	
Weathering	none	none	
Corrosiveness	none	none	
Other	none	none	

Table 3.12
VERMICULITE

Material Property	Value		Test Method
	Loose-Fill	Vermiculite Concrete	
Density	4 to 10 lb/ft^3	20 to 60 lb/ft^3	
K_{app} at 75F	0.33-0.41 Btu-in/ft^{2}hF	0.59-0.96 Btu-in/ft^{2}hF	ASTM C177
Thermal Resistance (R value) per 1" of thickness at 75F	3.0-2.4 hrft^{2}F/Btu	1.7-1.0 hft^{2}F/Btu	
Water Vapor Permeability	high	high	
Water Absorption	none	none	
Capillarity	none	none	
Fire Resistance	non-combustible	non-combustible	ASTM E136
Flame Spread	0	0	ASTM E84
Fuel Contributed	0	0	
Smoke Developed	0	0	
Toxicity	none	none	
Effect of Age			
a) Dimensional Stability	none	none	
b) Thermal Performance	none	none	
c) Fire Resistance	none	none	
Degradation Due To			
Temperature	none below 1000F	none below 1000F	
Cycling	none	none	
Animal	none	none	
Moisture	none	none	
Fungal/Bacterial	does not promote growth	does not promote growth	
Weathering	none	none	
Corrosiveness	none	none	
Odor	none	none	

SASKATCHEWAN STUDY-SUPER INSULATION


SIDING
THERMO-PLY
2×4 - 24 O.C.
DRY WALL
SHEET ROCK
PLYSCORD


SIDING
3/8" PLYWOOD
STYROFOAM
45 LB FELT ~
1/2" PLYWOOD
2×8" FRAMING 24 O.C.
SHEET ROCK

III. Behavioral Objectives

The final category of this insulation climate control enhancer unit is that of behavioral objectives. It should be noted that these objectives are in detail; only as much as necessary should be used at the middle/junior high school level. The senior high school level, however, should be capable of all suggested objectives. Since tools and equipment have been listed in a different section, only those material processes not otherwise covered will be presented here. Thus the student will be able to:

A. Do original research

  1. If building centered, the student will be able to find & interpret

    a. Zoning regulations re: insulation

    b. Building codes local, regional, & international re: insulation application locally

    c. Health ordinances in insulation use

    d. Determine construction data accessibility, choice of materials in application & weather factors

  2. If project centered: i.e., gather all pertinent

drawing and design data reflecting on the current project, i.e., all the above plus:

a. Public domain

b. State of the arts - status quo

c. Patent exclusions

d. Royalties

B. The student will now be able to analyze gathered data of original research utilizing 3 basic ingredients

1. If building centered - student will be able to evaluate and

a. Determine that the property/land will not be devalued, defaced, or otherwise damaged by solar-super insulation, etc., concept for the building design - but will enhance the community in appearance, activity, and income

b. Determine that the family/business and its life style will positively merge with the affected community, the land, and their combined well being.

        - c. Determine that the structure of this passive-solar energy super insulated, etc. Unit will harmoniously resolve the family/business, the land, and the community into positive action (into more such conceptual units)
    2. If project centered - student will be able to correctly analyze and:
        - a. Determine that original and tentative results are, in fact, valid and proven
        - b. Determine that no patent infringements exist
        - c. Determine that public will benefit therefrom
        - d. Determine that client will not be harmed physically, emotionally, and legally
        - e. Determine that ecology will not be damaged
        - f. Determine that current state of art is being enhanced

C. The student will be able to arrive at conclusions as objectively as possible

    1. If building centered
        - a. That insulation is vital for temperature control

    b. That some insulations are superior to others relative to specific applications
    c. That super insulation and structure design are compatible
    d. That the necessary permits, paper work, and signatures, etc., legally activate the construction
    e. That communications, supplies, deliveries, lodeing, sustenance, labor, capital, travel, good weather, local inspectors, etc., are immediately available.
    f. That a fundamental command of above process is essential via teacher/student evaluation

2. If project centered
    a. That insulation is essential for temperature control and will enhance and make the project both valid and viable
    b. That, therefore, all systems are go
    c. That progress begins with the first step into critical development and evaluation

    d. That the scientific method is functional and desirable

D. The student will be able to completely and correctly design and make all working drawings and details of the insulation inspired unit concept so as to be applicable for:

1. Buildings - - - i.e.,
    a. Temperature control within structure
    b. Unwanted temperature outside structure
        1. Complete climate control
        2. No heat loss or heat gain unless desired
    c. Application of most suited insulation for the structure
        1. In walls
        2. In ceilings/rafters
        3. In cellar/external foundation walls
        4. In cellar floor
        5. And movable insulation for windows and doors

2. Project/systems - - i.e.,
    a. Temperature control within object/unit
    b. No discomfort to user
    c. Application of most compatible insulation for functional demands of object/unit

E. The student will be able to search out and correctly use (confirmed by testing) research data relevant to design and building of the object/unit, i.e.,

1. Engineering research into insulation effectiveness
2. ASHRAE, ANSI, & AIA effected manuals
3. Manufacturers experimentation data
4. Relevant U.S. Government - HUD/freedom of information materials
5. Graphing relative to project
    a. Learn how to collect target data properly
    b. Learn how to design the most effective graph for the project
    c. Learn how to depict the assessed data correctly
    d. Learn how to interpret graph information functionally

    e. Learn how to properly apply this information

6. Charting - time, rectilinear, bar graphs, flow, operations and organization - - -
    a. Learn how to gather identified raw material correctly
    b. Learn how to design the most functional chart for the application
    c. Learn how to position the clarified information properly
    d. Learn how to evaluate any chart information objectively
    e. Learn how to correctly apply this information

7. Diagrams - motion, process, analysis, operative, identification
    a. Same as above graphs & charts
    b. " " " " "
    c. " " " " "
    d. " " " " "
    e. " " " " "

F. The student will be able to completely and correctly design and specify types and applications of insulations and discuss (show & tell) rules and techniques for functional systems dealing with the:

1. Abnormalities of "live" studding/rafters, & joists
2. Handling of tubing/piping for plumbing supply and waste lines
3. Handling of heating/cooling systems trunk, feeder, and raser ducting
4. Handling of electrical apparatus
5. Handling of foundation walls internal & external
6. Handling of obstructions to insulation
7. Handling of perimeter crawl spaces

G. The student will be able to recognize and correctly utilize the following insulation information:

1. R & V factors
2. Thermal radiation factors
3. Surface losses
4. Mass insulation factors
5. Seasonal temperature factors

H. The student will learn to determine and correctly use insulating values of K, C, and R for:

1. Building boards - wood/composition
2. Membrane
3. Flooring materials
4. Glazing - single and multiple
    a. Glass - green/white
    b. Plastics - rigid
5. Rigid insulating boards
    a. Styrofoam
    b. Polystyrene
    c. Polyurethane
    d. Polyisocyanurate
6. Flexible insulation
    a. Blankets
    b. Batts
    c. Reflective
    d. Loose fill
    e. Foam (now illegal in U.S.A.)

7. Thin weatherization plastic in rolled sheets
    - a. Polyethylene
    - b. P.V.C.
    - c. 4, 6, 8, 10 mil thicknesses

8. Asphalt bituminous saturated roofing felt
    - a. 15 LB roll
    - b. 30 LB roll
    - c. 45 LB roll
    - d. 60 LB roll

9. Air filled sealed polyethylene "bags"
    - a. 24" x 24" x 2" deep
    - b. 24" x 36" x 3" deep
    - c. 24" x 48" x 4" deep
    - d. 48" x 96" x 2" deep
    - e. Endless sheet, 2" deep (closed blanket)

10. All other manufactured materials
    - a. Metals
    - b. Fluids
    - c. Powders
    - d. Coatings - paints/clear finishes/stains, etc.

I. The student will be able to correctly resolve the effectiveness of any insulation by determining heat loss in BTU's for any contained unit which has a different temperature than the space in which the unit exists, i.e.,

1. BTU/hour heat loss = area x K
2. Heat loss = area of wall effectiveness x degree x temperature differential
3. Heat transmission coefficients = K or U factors
4. The derivation and using of:
   a. Heat loss = A x U x T
   b. When K = U x T and A = area
   c. BTU/hr = A x K
5. Understanding and using the relationship of R to U as reciprocal, i.e.,
   a. $U = \frac{1}{R}$
   b. $R = \frac{1}{U}$
   c. R x U = 1
6. Understanding that varying tables indicate limits of insulation effectiveness (diminishing returns).

Actually, life styles and demands of buyers determine this. The Saskatchewan studies clearly indicate more = better!

J. The students will be able to knowledgeably decide and correctly use insulation in its installation to protect against:

1. Toxicity (fumes)
2. Flammability
3. Carcinogenic agents
4. Respiratory irritation/allergies
5. Surface irritation of body/eyes
6. Improper measurement
7. Improper cutting and fitting
8. Improper stapling so as to lose reflective value
9. Improper stapler utilization
10. Improper stapler refilling – (incompatible staples)
11. Improper stapler maintenance and repair
12. Improper moisture barrier application
13. Moisture barrier leaks and potential leaks (tears)

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V. THERMAL STORAGE SYSTEMS

I. Introduction

Thermal storage systems can be defined as those which utilize one or more types of material (s) which absorb heat readily when exposed to an ambient temperature greater than its own and will give off heat freely when temperatures surrounding the material is less than its own.

II. Implementation

Materials commonly used as thermal mass include:

A. Masonry walls or floors including these made of concrete, stone, brick or adobe. They are primarily employed where air is used as a heat transfer medium. The most widely known application of a masonry heat storage wall is the Trombe wall (named after French architect and inventor, Dr. Felix Trombé). It is also one of the simplest and most effective means of providing such heat passively. It is a single-channel collector in which a section of the house wall (usually a space between south wall windows) becomes the heat absorber and thermal mass.

To do this the wall must be constructed with vents top and bottom. A general rule of thumb for vent size is to use twelve sq. inches of venting for every foot of solar wall width. The wall should be approximately one foot thick, but not less than six inches nor more than eighteen inches.

Double glazing is mounted in a weathertight, air tight, wood frame about four inches outside of and from the wall, to ensure flow of cool air into the floor level vents, up the face of the warm Trombe wall and back into the living space via the top vents. To prevent reverse flow at night, flap dampers are installed.

It is important not to surface the interior side of the wall with any material that would block heat radiation - particularly wood paneling. Even gypsum panels are not recommended. A thin coat of finish plaster or cement paint could be permitted if the natural masonry surface was found to be objectionable.

B. Water, in enclosed cans, drums, plastic bottles or other containers, is commonly used as a thermal mass because it is inexpensive, readily abailable, and an efficient heat storage medium. It can be used with systems employing air or water as a heat transfer medium. One common application of water in a thermal storage system is the water or drum wall.

This type of storage is particularly suited to retrofitting areas where major structural changes, such as those involving concrete and masonry walls, are undesirable. Water has other advantages over solid thermal mass storage materials. Among those advantages are:

1. Water stores about 2/3rds more heat per cubic foot than the next best material (dense rock).

2. The cylindrical or box type containers available for water can be mounted inside a building, behind a solar windows in the existing south wall of the house.

3. Because water is convective, it absorbs heat faster and transmits it to living spaces faster than the solids. (NOTE: Phase change materials are not treated as solids as a rule)

Any amount of water required for a water or drum wall can be calculated roughly at one half a cubic foot (four gallons) for each square foot of wall area. (example: if the south wall has room for two 6' x 8' solar windows backed by a twelve foot water wall, it would require 48 cubic feet or 364 gallons of water.) Because water weighs 62.5 pounds per cubic foot, special consideration must be given to proper floor support.

To complete the water wall, solar windows are cut into an exterior south facing wall. A false wall with vents top and bottom is built behind the water storage containers and becomes the new interior frame wall of the space to be heated. As with the Trombe wall, flap dumpers are installed in the vents to prevent reverse flow at night.

In operation, cool air enters at floor level of the wall from the interior area, rises along the face and, where possible, sides of the water container(s) and re-enters the interior area through the top vents.

C. Rocks - or rock bin storage as it is commonly known is primarily used in systems utilizing air as its heat transfer medium. The most efficient size rock is between one and two inches across to provide the proper amount of air circulation when piled together. They should be composed of high density material which has been thoroughly washed and is dust free. Used in conjunction with collectors, there should be approximately ½ cubic foot of rock for every square foot of collector area; or about two and one half times the amount of space required for an equal amount of water storage. Due to the large area required, rock bins are most often located beneath living areas of a structure.

D. Phase change materials are chemicals that store large amounts of heat by changing from a solid to a liquid. The most frequently used chemical is sodium sulfate decahydrate (commonly known as Glauber's salt). This is normally encapsulated in some kind of plastic tube or drum which is impervious to the chemical's caustic properties.

Unit for unit, phase change materials can store much more heat than water (as a liquid or rock, and this is a serious consideration when space for heat storage is limited.

Two of the major disadvantages of phase change materials have been 1) reduced effectiveness after a period of time due to chemical breakdown and 2) supercooling - stored heat isn't fully released at the chemicals melting point temperature.

It now appears, however, that these problems have been controlled and phase change materials with a performance guarantee of 10 years and more are available commercially from a number of manufacturers.

III. Behavioral Objectives

The objectives presented here are intended to serve as a guide for the classroom instructor; to be added to or modified as course level, time allotted and subject matter covered would dictate.

Upon completion of this unit, students will be able to:

A. Do original research: students will be able to find and interpret

1. If building centered

a. Zoning regulations

b. Building codes - local, regional, state

c. Other ordinances/codes

d. Site data - climate, geography, soil samples, etc.

e. Gather all pertinent data about the involved family or business to determine suitability of intended design.

2. If project centered: i.e., gather all pertinent drawing and design data reflecting on the current project, i.e., all the above plus:

a. Public domain

b. State of the arts - status quo

c. Patent exclusions

d. Royalties

B. The student will be able to analyze gathered data of original research utilizing three (3) basic ingredients:

1. If building cnetered, student will be able to evaluate and:

a. Determine that property/land will not be devalued, defaced, or otherwise damaged but will enhance the community in appearance, activity and income.

b. Determine that the family/business and its life style will positively merge with the affected community, the land, and their combined well being.

c. Determine that the structure of this passive-solar energy activated climate control system will harmoniously resolve the family/business, the land and the community into positive action.

2. If project centered, the student will be able to correctly analyze and:

a. Determine that original and tentative results are in fact valid and proven.

b. Determine that no patent infringements exist.

c. Determine that public will benefit from it.

d. Determine that client will not be harmed physically, emotionally, or legally.

e. Determine that ecology will not be damaged.

f. Determine that current state of the arts is being enhanced.

C. The student will be able to arrive at conclusions as objectively as possible.

1. If building centered, the student will be able to conclude that:

a. The climate control system is viable.

b. The necessary permits, paper work, and signatures, etc., legally activate the construction.

c. The communications, supplies, deliveries, lodging sustenance, labor, capital, travel, weather, protection, local inspectors, etc. are immediately available.

d. A fundamental command of above process is essential via teacher/student evaluation.

2. If project centered, the student will be able to conclude that:

a. The specific solar climate control concept and system (s) implementation are valid and thus viable - method is functional and desirable.

b. Legally all systems are go.

c. Progress begins with the first proper step into critical development and evaluation.

D. The student will be able to completely and correctly design and make all drawings and details of the passive solar thermal storage system, so as to be applicable for:

1. Buildings

Use all architectural data as per soil supportiveness/footings to mathematical weight/breakdown of structure - its dead weight and live weight - foundations, walls, beams, collumns, framing, etc. Details for calculating and drawing should include:

a. Plans

b. Elevations

c. Details

d. Tracings

e. Repros

f. Spec. listings

2. Projects/systems only. Students will correctly use and interpret the following formulas in all their parts.

a. The direct solar heat gain = (HG_{sol}) formula

1. $HG_{sol} = Agi \times I_t$

2. Where Agi = surface area of the unshaded portion of the glazed area in $Ft.^2$

3. Where I_t = solar heat gain through 1 $Ft.^2$ of glazing in BTU/day.

b. The heat gain formula from a thermal storage system into its targeted space area = $HG_{tm} = Agi \times I_t \times P$

1. Where Agi = surface heat gain through

unshaded portion of glazing in BTU/day

2. Where I_t = solar heat gain through 1 Ft.^{2} of glazing in BTU/day

3. Where P = the percentage of incident energy on the face of the thermal storage system that is transferred to the (living) space.

c. Students will be able to perform the above calculations for thermal storage systems which employ any of the following materials as a storage medium:

1. Water
2. Masonry, concrete, adobe, earth
3. Rock bin
4. Phase change materials

E. The student will be able to define, describe, identify, and otherwise explain the importance of the following in relation to solar thermal storage systems.

1. Thermal mass according to:

   Weight in lbs. x specific heat
2. Specific heat
3. Direct storage
4. Indirect storage

5. The effect of thermal mass on the rate of temperature rise and fall
6. Surface color as applied to heat absorption and reflection
7. Insulation
8. Ventilation
9. Radiation
10. Heat flow (heat gain and heat loss)
11. Glazing
12. Convection
13. Siting
14. Conductors
15. New developing systems not yet fully approved (still experimental)
    a. Metal lathe as collectors
    b. Venetion blinds as collectors & rejectors
    c. Flat black painted non-masonry/metals surfacing
    d. Plds newer materials

F. The student will now be able to correctly test the

the thermal storage and cooling systems whether masonry, water, rocks or phase change in complete climate-control mode for efficiency and refinements, i.e.,

1. Wall thickness
2. Wall/floor coloration
3. Wall venting
4. Drum/container size
5. Drum coloration
6. Drum/container positioning
7. Phase-change tube frequency
8. Phase-change tube coloration
9. Phase-change tube placement
10. Applied insulation to all above
11. Thermal chimney effectiveness

G. The student will now be able to apply the thermal-storage and cooling concepts to:

1. Barns
2. Chicken coops
3. Dog houses
4. Garages
5. School rooms
6. Small commercial structures
7. Recreational purposes
8. Transportation
9. Etc.

VI. ROOF - POND OR SKY THERM CLIMATE - CONTROL SYSTEMS

I. Introduction

Roof-pond also known as sky therm climate - control systems are those heating and cooling, i.e., climate control - - - passive solar units which contain the thermal mass on top of ceilings of inhabited spaces, specifically, this means within the roof structure on flat roof buildings and on attic floors for sloped (gable type) roofs.

The thermal mass composition is contained water, either in plastic bags or in tanks of metal or fiberglass. Seldom is concrete used becuase of its poor conductivity.

This mass is so arranged as to be in direct contact with the top of the inhabited space ceiling(s). In both cases, whether bags, or tanks, this is essential if heat transfer is to occur for either heating, into the space or cooling, out of the space.

Therefore, very pliable thin long lasting materials must be utilized for waterproofing to ensure as direct a contact and as little insulation via thickness build-up of waterproofing as possible. In the case of tanks, their bottoms all joined together as an integral unit would be the ceiling.

II. Implementation

There are three (3) basic roof layouts for pond collection implementation.

A. Flat roofs without protective glazing, where insulating exterior roof panels are moved via tracks inparallel to ponds for pond exposure. This simple method is most efficient in the lower latitudes, 28° to 30° NL

B. Flat roofs with protective glazing under the roof-panels covering the ponds are apparently effective between 32° NL to 38° NL. In addition, reflective insulation is applied to the panels so that proper tilting will direct the solar rays into the ponds.

C. Further north from 38° NL to the extreme of 56° NL two different roof styles appear. First, stepped flat roofs - upward from S. to N. Secondly, sloped (gable type) roofs with the ridge running E. to W. - the former, has folding relective panels and protective double-glazing. The latter, has the southern sloped deck double glazed with the pond on the attic floor protected by insulation. In both cases, the reflective insulation is so arranged as to super-concentrate the solar rays into the ponds.

D. It should be noted here that, whether bag or tank, the bottoms should be flat black with absolutely clear tops so that the solar rays can penetrate to the very bottom black, thus insuring moderate temperature control with minimal stratification of temperature.

E. In addition H_2O evaporation must be a controlled factor and proper drainage gutters designed and installed atop the insulating air bags. This will insure speedy drainage and minimal heat loss via evaporation when in the heating mode. The converse is true for desired heat loss when in the cooling mode.

III. Behavioral Objectives

The final category of this roof-pond climate-control unit is that of behavioral objectives. It should be noted that these objectives are in detail with considerable depth - - - middle or junior high school application; only as much of the suggested depth as is necessary ought to be used.' The senior high school, however, should be capable of all the suggested objectives.

Since tools and equipment have been listed in a different area of this document, only those material/processes not otherwise covered will be presented here. Therefore, upon completion of the following ten major activity units, the student will be able to:

A. Do original research - - - all pertinent information
    1. If building centered, student will be able to find and interpret
        a. Zoning regulations
        b. Building codes - local, regional, state, national (if required)
        c. Other ordinances/codes
        d. Site data - climate, geography, soil

samples, H_2O availability, geology, sewage disposal access, utility services, local labor, access to construction materials, communication, travel, lodging/sustenance, weather, etc.

e. Gather all pertinent data about the involved family or business and its life-style, socio/economic, health, emotional, philosophy, ecology, etc.

2. If project centered, i.e., gather all pertinent drawing and design data reflecting on the current project, i.e., all the above plus:

   a. Public domain

   b. State of the arts - status quo

   c. Patent exclusions

   d. Royalties

B. The student will be able to analyze gathered data of original research utilizing three (3) basic ingredients - - -

1. If building centered - student will be able to evaluate and:

   a. Determine that the property/land will not be devalued, defaced, or otherwise damaged, but will enhance the community in appearance, activity, and income.

b. Determine that the family/business and its life style will positively merge with the affected community, the land, and their combined well being.

c. Determine that the structure of this passive-solar energy activated roof-pond climate-control system will harmoniously resolve the family/business, the land, and the community into positive action.

2. If project centered - student will be able to correctly analyze and:

   a. Determine that original and tentative results are in fact valid and proven.

   b. Determine that no patent infringement exist.

   c. Determine that public will benefit therefrom.

   d. Determine that client will not be harmed physically, emotionally, legally.

   e. Determine that ecology will not be damaged

   f. Determine that current state of arts is being enhanced.

C. The student will be able to arrive at conclusions as objectively as possible.

1. If building centered, the student will be able to conclude that:
    a. The roof-pond climate-control concept structure is viable.
    b. The necessary permits, paper work, and signatures, etc., legally activate the construction.
    c. That communications, supplies, deliveries, lodging - sustenance, labor, capital, travel, weather protection, local inspectors, etc., are immediately available.
    d. A fundamental command of above process is essential via teacher/student evaluation.
2. If project centered, the student will be able to conclude that:
    a. The roof-pond climate-control concept and system (s) implementation are valid and thus viable.
    b. Legally all systems are go.
    c. Progress begins with the first proper step into critical development and evaluation.
    d. Scientific method is functional and desirable.

D. The student will be able to completely and correctly design and make all working drawings and details of the structure integrated roof-pond climate-control system(s) concept so as to be applicable for:

1. Buildings

   Use all architectural data as per soil supportiveness/footing to mathematical weight/breakdown of house - its dead weight and live weight - foundations, walls, beams, columns, framing and attic/roof, etc., details for calculating and drawing:

   a. Plans
   b. Elevations
   c. Details
   d. Tracings
   e. Reproductions (B or W prints)
   f. Spec. listing

2. Project/system(s) only, and thus correctly use and interpret the following formulas in all their parts:

   a. The direct solar heat gain = (HG_{sol}) Formula

      1. $HG_{sol} = Agl \times I_t$

2. Where Agi = surface area of the unshaded portion of the glazed area in Ft.^{2}

3. Where I_t = solar heat gain through 1 Ft.^{2} of glazing in BTU/day

b. The heat gain formula from a thermal storage roof pond system into its targeted space area = (HG_{tm})

1. $HG_{tm} = Agi \times I_t \times P$

2. Where Agi = surface area of the unshaded portion of the glazing in Ft.^{2}

3. Where I_t = solar heat gain through 1 Ft.^{2} of glazing in BTU/day

4. Where P = the percentage of incident energy on the face of a thermal roof-pond that is transferred to the (living) space

c. The conversion formula of total space heat gain into units more convenient to use (BTU/day – $SqFt_{fl}$) = HG_{sp}

$$HG_{sp} = \frac{HG_{sol}}{A\ floor} + \frac{HG_{tm}}{A\ floor}$$

Where HG_{sp} = total space heat gain/$Ft.^2$ of floor area

d. The formula for determining average indoor temperature

1. $$t_j = \frac{HG_{sp}}{U_{sp}} + t_o$$

2. Where HG_{sp} = rate of space heat gain in BTU/day - Ft^2_{fl}

3. Where U_{sp} = rate of space heat loss in BTU/day - Ft^2_{fl} - ^oF

4. Where t_o = average daily outdoor temp.

e. The formula for determining daily space temperature fluctuations is relatively simple for any roof-pond system. Simply put: space temperature fluctuations for a roof-pond are proportional to the depth of the pond, as the depth increases, the fluctuation decreases.

f. The auxiliary heat requirement formula (Q_{aux}) if, indeed, required will be:

1. $Q_{aux} = Q_r - Q_c$

2. Where Q_r = monthly space heating requirements in BTU's

3. Where Q_c = monthly solar heating contributions in BTU's

4. When $Q_c >$ than Q_r, then $Q_{aux} = 0$

g. The formula for monthly space heating requirements (Q_r) will be:

1. $Q_r = U_{sp} \times A_{floor} \times DD_{mo}$

2. Where U_{sp} = rate of space heat loss in BTU/day - Ft^2_{fl} - ^oF (including the rate of heat loss through south glazing thermal storage ponds

3. Where A_{floor} - floor area of the space in Ft^2

4. Where DD_{mo} = degree days/month

h.[1] The formula for monthly solar heating contribution (Q_c) for direct gain systems - roof-ponds

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[1] Ibid. page bottom page 296 footnote

1. SLR = monthly solar load ratio

2. $$\therefore \quad SLR = \frac{\text{monthly solar energy absorbed}}{Q_r}$$

3. Where the monthly solar energy absorbed = $A_{gl} \times I_t \times$ surface absorptance × days/month

4. Where A_{gl} = surface area of unshaded glazing in Ft^2

5. Where I_t = average daily solar gain through one Ft^2 of glazing in BTU/day

6. Where solar absorptance = the percentage of solar energy absorbed within the thermal mass of the pond - dark and deep = 0.95 - - for a light and shallow pond - = 0.90

i. The formula[1] for determining cost effectiveness

$$\begin{array}{l}\text{Cost of}\\ \text{Solar}\\ \text{Heat}\end{array} = \frac{\left(\begin{array}{c}\text{solar}\\ \text{system}\\ \text{cost}\end{array} \times \begin{array}{c}\text{capital}\\ \text{recovery}\\ \text{factor}\end{array}\right) + \begin{array}{c}\text{annual operating}\\ \text{and maintenance}\\ \text{cost}\end{array}}{\text{annual solar heating contribution}} = (Q_{cyear})$$

3. The student will be able to properly utilize:

a. Graphs (bar, line, circle, pictogram, pictorial), i.e.,

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[1] Ibid. page 298 bottom footnote

    1. Learn how to collect targeted data properly
    2. Learn how to design the most effective graph for the job
    3. Learn how to depict the assessed data correctly
    4. Learn how to interpret graph information functionally
    5. Learn how to properly apply this information

b. Charts (time, rectilinear, bar graphs, flow, operations and organization)

    1. Learn how to gather identified raw material correctly
    2. Learn how to design the most functional chart for the application
    3. Learn how to position the clarified material properly
    4. Learn how to evaluate any chart information objectively
    5. Learn how to correctly apply this information

c. Diagrams (motion, process, analysis, operative, identification)

1. Same as above graphs and charts
2. " " " " " "
3. " " " " " "
4. " " " " " "
5. " " " " " "

d. Tables for research and documentation re: their correct use and application - most common

1. Number/letter
2. Conversion
3. Fraction
4. Decimal
5. Root/log
6. Threaded fasteners
7. Washers
8. Pins
9. Keys
10. Bushings
11. Flat stool
12. Key
13. Rivet
14. Standard ga. sheet metal

15. Standard ga. wire size and dec. equiv.

16. Nail fasteners

17. Geometric formulas

18. Weights of materials

19. Drill sizes

20. Plumbing det's

21. Welding det's

22. Elec/ronic det's

23. Solar energy det's

4. The student will be able to correctly plan, construct, and use:

    a. Shade lines

    b. Solar radiation calculator

    c. Shading calculator mask

5. The student will be able to determine properties of

    a. Solid materials

        1. Woods

        2. Metals

        3. Plastics

    b. Liquid materials

        1. H_2O

    2. Anti-freeze
    3. Lub - oil
    4. Hydro fluid

6. The student will learn and correctly use insulating values of K, C, & R for:
    a. Building boards - wood/composition
    b. Membrane
    c. Flooring materials
    d. Glazing - single & multiple - glass/plastics
    e. Rigid insulating boards
        1. Styrofoam
        2. Polystyrene
        3. Polyurethane
        4. Polyisocyanurate
    f. Flexible insulation
        1. Blankets
        2. Batts
        3. Reflective
        4. Loose fill
        5. Foam

g. Thin weatherization plastic-rolled sheets

   1. Polyethylene
   2. P.V.C.
   3. 6, 8, 10, mil thicknesses

h. 4 to 6 mil enclosed polyethylene bags (sealed)

   1. 24" x 24" x 2" depth air filled
   2. 24" x 36" x 3" " "
   3. 24" x 48" x 4" " "

7. The student will be able to correctly resolve heat loss in BTU's for any space containment, using

   a. BTU/hour heat loss = area x K , i.e.,

   b. Heat loss = area x wall effectiveness x degree x temp-diff

   c. Heat transmission coefficients = K or U factors

   d. ∴ Derivitively

      1. Heat loss = A x U x T
      2. When K = U x T & A = area
      3. $\therefore BTU/HR_{loss} = A \times K$

8. The student will now finally, putting all this previous conceptual information to use, be able to correctly resolve the pond-roof climate-control system (s) into the design stage.

    a. For latitudes of 28°N to 30°N as flat roof unglazed
    b. For latitudes of 32°N to 36°N as glazed flat roof
    c. For latitudes of 38°N to 56°N as sloped/stepped roof glazed

9. The student will now be able to correctly design the integral roof-pond internal structure(s), i.e.,
    a. Determining the items and weights of involved materials
        1. Channeled 40 mil metal roof decking
        2. Steel track beam(s)
        3. Reinforced plastic roofing panels 2 to 3 in thickness with knowledge about:
            a. Material longevity
            b. Material expense
            c. Maintenance considerations
            d. Ease of repair
            e. Toxicity
            f. Flamability
            g. Reinforcement
            h. Wind resistance
            i. Snow load

4. Track system materials
    a. Guides/glides
    b. Weatherization stops
    c. Pulleys
    d. Gearing
    e. Rollers
    f. Hinges
    g. Pins
    h. Stops
5. Threaded fasteners
6. Power control unit or manual device(s)
7. Black laminated polyethylene liner for H_2O proofing contact deck area
8. Asphalt sealant
9. Clear P.V.C. H_2O containment bags and seals
10. Clear P.V.C. air insulation inflated cell over H_2O bags
11. Steel beam track insulation
12. Track beam seals - P.V.C. flaps
13. Evaporative drainage gutters (cooling)

14. Reflective insulation sheets - polished Al., SS., etc.
15. Roof-pond metal tank system-s.s./integral T. deck
16. Roof-pond fiber glass tank system integrated with deck
17. Black paint - H_2O resistant for tank bott/sides
18. Clear plastic glazing for tank tops with interlock and seals
19. Metal accoustical ceiling
20. Distilled H_2O for ponds (non-corrosive)
21. Assembly/H_2O proofing miscellanea
    a. Rivets
    b. Sheet metal screws
    c. Weldments, means for
    d. Caulking
    e. Tapings, etc.

b. Determining average load calculation for supportive structures

   1. Walls

        2. Columns
        3. Posts
        4. Beams
        5. Plates - etc.
    c. Determine target - area soil resistance
        1. Soil composition
        2. Footings
        3. Foundations
        4. Insulation/moisture control

10. The student will now be able to obtain the roof-pond system materials, i.e.,
    a. Commercial purchase of stock materials
    b. Commercial purchase of available pre-assembled units
    c. Commercial purchase of non-stock items for fabrication purposes
    d. Effect delivery of required materials to field site

11. The student will now be able to correctly fit and assemble the roof-pond integrated structure, i.e.,
    a. Flat and open roof-pond system

b. Flat and glazed roof-pond system

c. Sloped/stepped and glazed roof-pond system(s)

   1. Determine differences between pliable plastics - sans heat
      a. Polyethylene clear
      b. Polyvinyl chloride, PVC clear
      c. Black polyethylene laminated
      d. Heat loss
      e. Longevity
      f. H_2O proof jointing
      g. Ease of working

   2. Determine differences between rigid plastics
      a. Fiberglass, clear
      b. Lucite, clear
      c. Acrylic, clear
      d. Fiberglass, black opaque
      e. Heat loss
      f. Longevity
      g. H_2O proof jointing
      h. Ease of working

3. Determine differences (suitability) of asphalt-impregnated rolled building felt - 10 to 45 lb., in lieu of plastics, hot tarred

   a. Pliability - all temps

   b. U.V. abuse

   c. H_2O tolerance

   d. Longevity - dry and wet

   e. Heat loss

   f. H_2O proof jointing

   g. Ease of working

4. Determine effect of ultra violet (U.V.) exposure to previous listed plastics

5. Determine U.V. resistance/inhibitiveness in plastics

6. Determine immediate and potential leakage sources:

   a. Poor alignment of framing/decking

   b. Obvious burrs, any metals

   c. Obvious ridges, metals, hard plastics

   d. Sharp edges

   e. Irregular ends - offsets

f. Rough surfaces

g. Obvious foreign matter (slivers, stones, rivets, nuts, etc., oil - grease -)

h. Protruding fasteners into and too close to pond bags/liner

i. Sharp weldments - sparking, etc.

j. Rivet clinching sharp edges

k. Etc.

7. Determine functionality of best available plastics and utilize same for:

a. Inner roof-pond decking H_2O proofing application

b. Asphalt sealant

c. Black laminated polyethylene liner

d. Clear PVC H_2O bag(s) filling with distilled H_2O

e. Utilizing of U.V.-inhibited clear .018 in PVC for insulated air cell atop the filled and sealed H_2O bags

f. Installation of gutters/seals

8. Determine the safe (no leakage) filling and positioning of all seals, liners, and containers

   a. Possible sharp/burred conditions not previously noted

   b. Possible evidence of potential leakage - stretching, rubbing, pinching

   c. Poor joints - improper original sealing - poor adhesive, incorrect application

   d. Etc.

12. The student will also be able to correctly fit and assemble the 2 alternate roof-pond containment integrated deck-pond systems, i.e.,

   a. The fiberglass system tank roof deck

   b. The stainless steel system tank roof deck

      1. Know that these are without the plastic-bag H_2O containers

      2. Know that these are internally coated with a compatible H_2O resistant black paint

      3. Know that these require extra H_2O leakage check testing

    4. Know that these integrated roof-container deck systems require clear U.V. inhibitive plastic positive-lock covers
    5. Know that these internal containment "ponds" are not affected by burrs, sharp edges, protrusions, etc.
    6. Know that minimal caulking, emulsion, etc., will deter heat transfer to the ceiling and thus be counterproductive

13. The student will also be able to determine via prior compatable observation/experiences the validity of concrete decking
14. The student will now be able to correctly fit and assemble the protective reinforced-plastic roofing panels, i.e.,
    a. Framing details
    b. Alignment to eliminate heat loss bleeding
    c. Tracking/glide-rolling details
    d. Fine-tuning track-beam positioning to panels
    e. Hinging for solar reflection
    f. Apply and adjust additional weatherization requirements

    g. Apply control mechanism (s) to control pond exposure
    h. Apply power or counterweight methods for inducing panel movement
    i. Create checking and maintenance/repair procedures

15. The student will now be able to correctly size and apply the proper reflective insulation.

16. The student will now be able to check, adjust, and fine-tune the system for maximum efficiency (minimum heat loss).

17. The student will now be able to fit and correctly assemble the glazing for:

    a. Maximum weather protection
        1. Rain
        2. Snow
        3. Hail
        4. Wind
    b. Maximum structural protection (slope/gable)
        1. Ease of snow removal
        2. Minimal icing
        3. Minimal snow accumulation
    c. Total reflective insulation protection

18. The student will now be able to weatherize the external roof panels surfacing area if needed.

19. The student will now be able to properly plan and design an appropriate ceiling for the deck undersiding, i.e.,

    a. Smoothing of surface

    b. Painting of surface, thinnly!

    c. Applying an accoustical steel "skin"

       Know that maximum metal to metal contact for best heat transfer is essential

        1. . ' . Fasten with F.H. screws
        2. Fasten with pop rivets
        3. Fasten with tack welds
        4. Finish surface, thin coat!

    d. Checking for and controlling perimeter heat loss

20. If a building, then student will be able to knowledgeably introduce heat moderating controls - lower highs, higher low temps, i.e.,

    a. Masonry veneering all internal perimeter walls

    b. Internal masonry partitions

    c. Masonry veneering bearing columns

21. The student will now be able to correctly test the total roof-pond climate-control efficiency, i.e.,

   a. Arriving at 100% heating/cooling modes
   b. Obtaining minimal (2° to 4°F) temp variations between floor and ceiling
   c. By adjusting ponds H_2O depth (deeper)
   d. By adjusting reflection angles for better heating

22. The student will now be able to correctly apply the roof-pond climate-control system to:

   a. Barns
   b. Chicken coops
   c. Dog houses
   d. Garages
   e. Public sports arenas
   f. School rooms/field houses/gyms
   g. One story commercial structures
   h. Any compatible auxiliary device for summer camping food preservation
   i. Churches
   j. Buses
   k. Planes
   l. Ships
   m. Autos
   n. Trucks
   o. Etc.

VII.

SUNSPACE: GREENHOUSES AND ATRIUMS

I. Introduction

Glass easily transmits short wave radiation, but is a poor transmitter of long wave radiation. Once the sun's energy has passed through a sheet of glass and has been absorbed by a material behind it, the heat will not be readily re-radiated to the outside. As a consequence, a glassed-in area, exposed to the sun acts as a heat trap.

II. Implementation

This unit explores two special kinds of heat traps used in passive solar heating: greenhouses and atriums.

A. Greenhouses (often called sunrooms or sunspace), can perform two key passive design roles.

1. As secondary skins - effectively raising the temperature just outside the buildings exterior wall in the winter and

2. As passive solar collectors - a greenhouse can be constructed as a secondary skin on any facade - but a south-

facing greenhouse makes the best passive solar collector. Other factors should also be considered:

a. The wall between the greenhouse and the residence must be insulated to control heat flow and prevent over heating.

b. Those surfaces directly exposed to the sun should be of dark - color to absorb the maximum amount of heat. Floors should be light - colored if there is a danger of them becoming too warm and dark if additional warmth is desired.

c. After the sun has gone down, some type of insulated shutters or shade should be used in order to retain the heat collected.

d. The distance from the exterior wall of the greenhouse to another object on the landscape (a tree, another building, etc.) should be at least 2½ times the height of the wall to assure solar access.

During the winter, the sun rises in the southeast. For this reason, south facing glazing collects the maximum amount of light available at this time of the year. Glazing is glass or plastics material which allows sunlight to pass through. Frequently, glazing is tilted at about 60° from the horizontal to maximize light transmission during the winter months. The sun reaches no more than about 30° above the horizon at its highest point (solar noon) during the winter, resulting in the shortest days of the year.

Vertical glazing works nearly as well during mid-winter days, especially in areas where snow cover helps reflect extra light into the greenhouse. By designing the greenhouse to be no more than 8 to 10 feet deep, you can ensure that low winter sun will penetrate all the way to the back of the structure. Inside the greenhouses, all surfaces which do not serve as thermal mass should be painted a light color to help reflect light back to plants and thus, help them grow evenly or dark colored for additional heat, if not used for plant life.

Probably the first thing that must be considered when constructing a greenhouse is where to put it. A south facing wall of a house or structure is the ideal place, but shading, space, or access problems may indicate the southeast or southwest instead. The winter performance will be nearly equal for any orientation within 30° of south. A greenhouse which covers a window or door will make venting warm air to your structure easy.

To conserve the maximum amount of heat, solar greenhouses in the Northeast are designed with double glazing and also include insulating shades or curtains to be used at night. Careful construction prevents air "leaks".

Heat loss is further reduced by insulating all or most of the East and West end walls and part of the roof. This, in addition to the thermal chimney effect of roof ridge venting, etc., will also serve to keep the greenhouse cooler in the summer. Thermal mass, which is an essential part of the solar greenhouse, is discussed in detail in the unit entitled Thermal Storage Systems.

B. Atriums - traditionally, this is a centrally located, open court within a structure, surrounded by enclosed space and open to the sky. If a major fraction of a building's exterior glass area can be orientated inward to the atrium, energy savings will result:

1. By reducing heat losses through and around windows on the exterior wall of the structure and,

2. By using the atrium as a heat trap (passive solar collector).

To maximize the passive solar collector aspect, it is best if the atrium is covered with a skylight and insulating shutter, (to keep the heat in when the sun goes down and to provide shading during times of unwanted solar gain).

III. Behavioral Objectives

The objectives presented here are intended to serve as a guide for the classroom instructor; to be added to or modified as course level, time allotted and subject matter covered would dictate.

Upon completion of this unit, students will be able to:

A. Do original research: students will be able to find and interpret:

1. If building centered:
    a. Zoning regulations
    b. Building codes - local, regional, state
    c. Other ordinances/codes
    d. Site data - climate, geography, soil samples, etc.
    e. Gather all pertinent data about the involved family or business to determine suitability of intended design.
2. If project centered: i.e., gather all pertinent drawing and design data reflecting on the current project, i.e., all the above plus:
    a. Public domain
    b. State of the arts - status quo
    c. Patent exclusions
    d. Royalties

B. The student will be able to analyze gathered data of original research utilizing three (3) basic ingredients:

1. If building centered, student will be able to evaluate and:
    a. Determine that property/land will not be devalued, defaced, or otherwise damaged but will enhance

the community in appearance, activity and income.

b. Determine that the family/business and its life style will positively merge with the affected community, the land, and their combined well being.

c. Determine that the structure of this passive-solar energy activated climate control system will harmoniously resolve the family/business, the land and the community into positive action.

2. If project centered, the student will be able to correctly analyze and;

   a. Determine that original and tentative results are in fact valid and proven

   b. Determine that no patent infringements exist

   c. Determine that public will benefit therefrom

   d. Determine that client will not be harmed physically, emotionally, or legally

   e. Determine that ecology will not be damaged

   f. Determine that current state of the arts is being enhanced

C. The student will be able to arrive at conclusions as objectively as possible.

1. If building centered, the student will be able to conclude that:
    a. The climate control system is viable
    b. The necessary permits, paper work, and signatures, etc., legally activate the construction
    c. That communications, supplies, deliveries, lodging sustenance, labor, capital, travel, weather protection, local inspectors, etc. are immediately available.
    d. A fundamental command of above process is essential via teacher/student evaluation.
2. If project centered, the student will be able to conclude that
    a. The specific solar climate control concept and system (s) implementation are valid and thus viable; method is functional and desirable.
    b. Legally all systems are go
    c. Progress begins with the first proper step into critical development and evaluation

D. The student will be able to completely and correctly design and make all working drawings and details of the passive solar greenhouse or atrium, so as to be applicable for:

1. Buildings centered

    a. Use all architectural data as per soil supportiveness/footings to mathematical wt./breakdown of house - its dead wt. and live wt. - foundations, walls, beams, columns, framing and roof, etc. Details for calculating and drawing should include:

        1. Plans
        2. Elevations
        3. Details
        4. Tracings
        5. Repros
        6. Spec. listing

2. Project/system(s) only, and thus correctly use and interpret the following formulas in all their parts:

    a. The direct solar heat gain formula:

$$HG_{sol} = A_{gl} \times I_t$$

1. Where A_{gl} = surface area of unshaded portion of the glazed area in square feet

2. Where I_t = solar heat gain through 1 ft^2 of glazing in BTU/day

b. The heat loss formula

$$H = \frac{A \times (T_{in} - T_{out})}{R}$$

1. Where H = heat loss in BTU/hour

2. Where T_{in} = inside temperature, °F.

3. Where T_{out} = outside ambient temperature, °F

4. R = thermal resistance

5. A = area in square feet

c. Thus the student will be able to compute the net total heat gain or loss

E. The student will be able to define, describe, identify, and otherwise explain the importance of the following in relation to greenhouses and atriums

1. The 3 major types of greenhouses:

a. Free standing

b. Pit

c. Attached

2. Two principle angles formaed by the sun in reference to our location on the earth

   a. Altitude } During winter solstice
   spring/fall equinox
   b. Azimuth } summer solstice

3. Siting

4. Conductors

5. Insulators

6. Infiltration

7. Ventilation

8. Heat flow - (heat gain and heat loss)

9. Transmittance

10. Thermal mass < Direct / Indirect > storage

11. Glazing

12. British Thermal Unit

F. The student will now be able to correctly test the climate control efficiency of the sunspace/atrium systems and make refinements thereto.

   1. Glazing

   2. Size of space

   3. Placement of internal drums/walls

4. Insulation

5. Thermal chimney system

G. The student will now be able to correctly apply the sunspace/atrium system to:

1. Other buildings - retro
2. Animal shelters
3. Fowl shelters
4. Recreational purposes
5. Transportation devices
6. Etc.

VIII.

SOLAR DOMESTIC HOT WATER SYSTEMS

I. Introduction

The objective of this unit on active solar systems is to introduce and explain how the integral components of a system function and contribute in the collection and storage of solar radiation energy.

A. Identification of Energy Problems

1. Objective

   To enable students to identify the causes of the energy problem and that potential solar energy can contribute to relieving this problem.

2. Topics of Discussion

   a. Growth of demand for energy (gas, coal, oil) worldwide

   b. Growth of demand in the U.S.

      Environmental advantages to solar energy related to other energy sources.

   c. How will future demands for energy be met?

   d. Percentage of home energy use for hot water, solar contribution

B. General System Operation

1. Objective

   To enable the student to understand the general operation of a solar collection system whether panel or batch Hot Water Heater.

2. Topics of Discussion

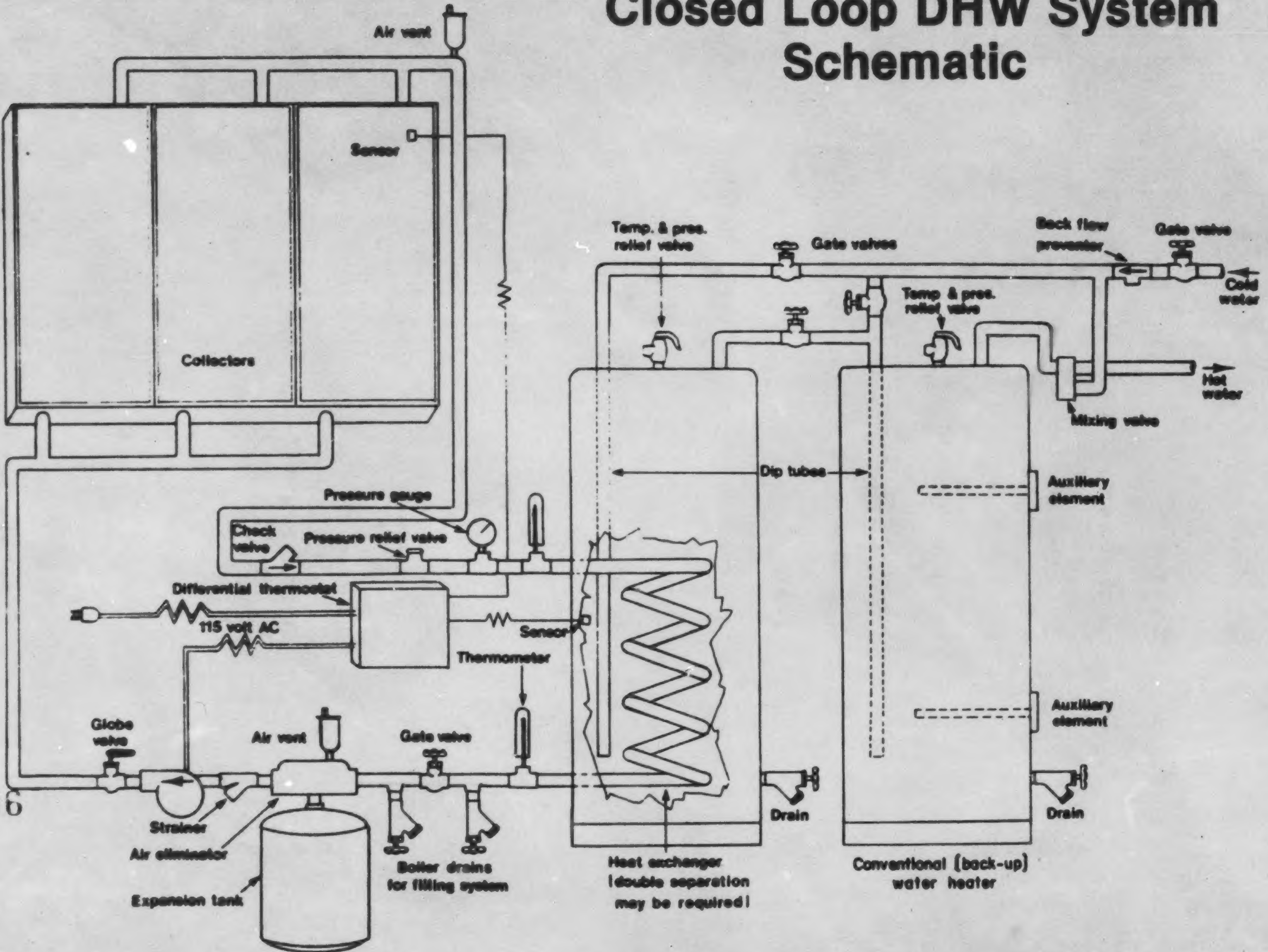
   a. Physical components of a typical panel system

      1. Collectors and solar radiation
      2. Storage
      3. Heat transfer medium
      4. Movement of medium
      5. Heat exchangers
      6. System control

   b. Physical components of a batch heater system

      1. Large storage tank for solar exposure
      2. Suitable housing for same
      3. Double glazing for top
      4. Suitable insulation for sides, ends, and bottom
      5. Suitable anchors for system
      6. Internal storage tank
      7. Transfer medium/control

Closed Loop DHW System Schematic


Air vent
Sensor
Collectors
Temp. & pres. relief valve
Gate valves
Back flow preventer
Gate valve
Cold water
Temp & pres. relief valve
Hot water
Mixing valve
Dip tubes
Auxiliary element
Pressure gauge
Check valve
Pressure relief valve
Differential thermostat
115 volt AC
Sensor
Thermometer
Auxiliary element
Globe valve
Air vent
Gate valve
Drain
Drain
Strainer
Air eliminator
Expansion tank
Boiler drains for filling system
Heat exchanger (double separation may be required)
Conventional (back-up) water heater

Source: Installation Guidelines for Solar DHW Systems

C. Introduction to the Domestic Hot Water System (D.H.W.)

1. Objectives
    a. To provide a brief description of a D.H.W. system
    b. To familiarize the student with the various parts found in a D.H.W. system
    c. To provide the student with a basic understanding of what happens when the system is functioning
    d. What's happening when the system is not functioning to provide D.H.W.
2. Topics for Discussion
    a. Solar radiation
    b. Collectors, panels and batch tanks
        1. Glazing
        2. Collector housing
        3. Absorber plates
            a. Construction
            b. Surfaces (heat absorbing)
            c. Materials (absorber plates)
        4. Insulation
            a. Types
            b. Advantages and disadvantages

5. Sealants
6. Stagnation
    a. High limit
    b. Loss of power

D. Collector Orientation and Site Evaluation

1. Objective

The student will be able to determine solar south using different techniques

2. Topics for Discussion

Methods used to determine solar south

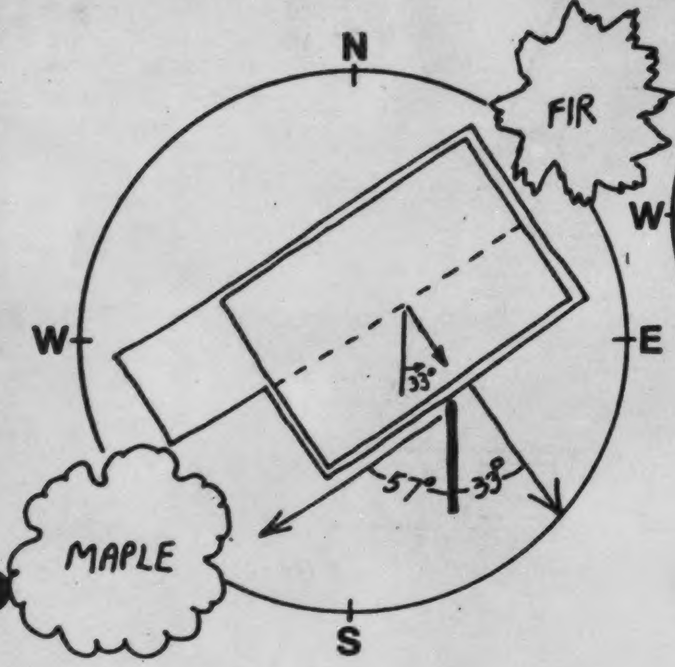
- a. Magnetic South
    - 1. Compass
    - 2. Isogonic chart
- b. Solar or True South
- c. Solar Noon
- d. Solar Window

SOLAR SITE PLAN

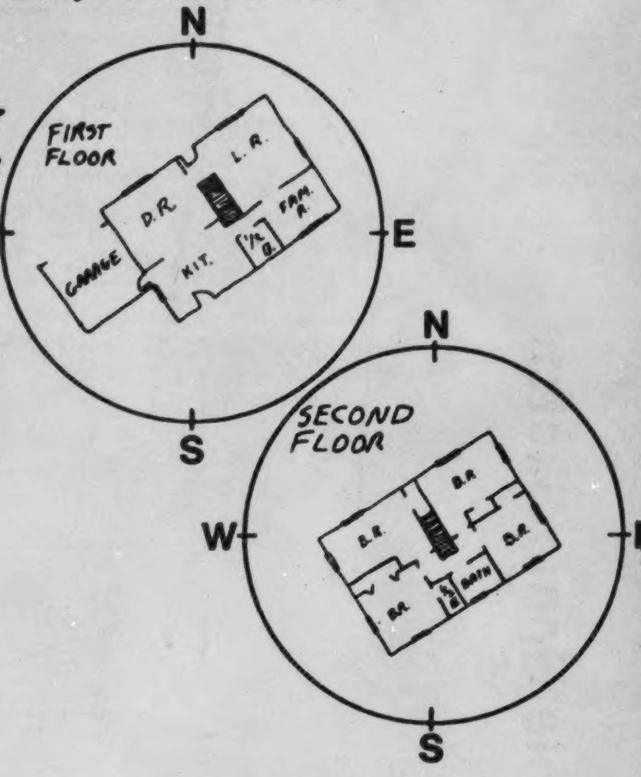
SKETCH PAGE

(SAMPLE)

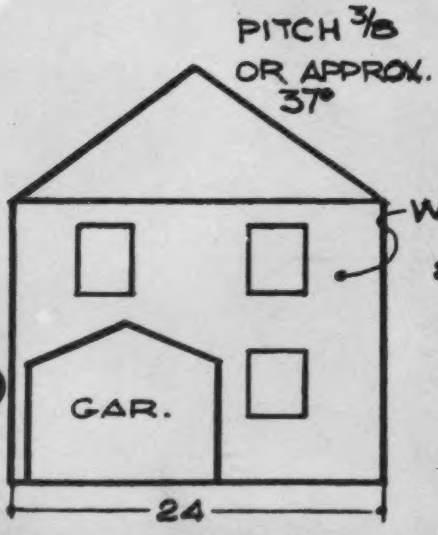
TOP VIEW


N
W
E
S
FIR
MAPLE
33°
57°
33°

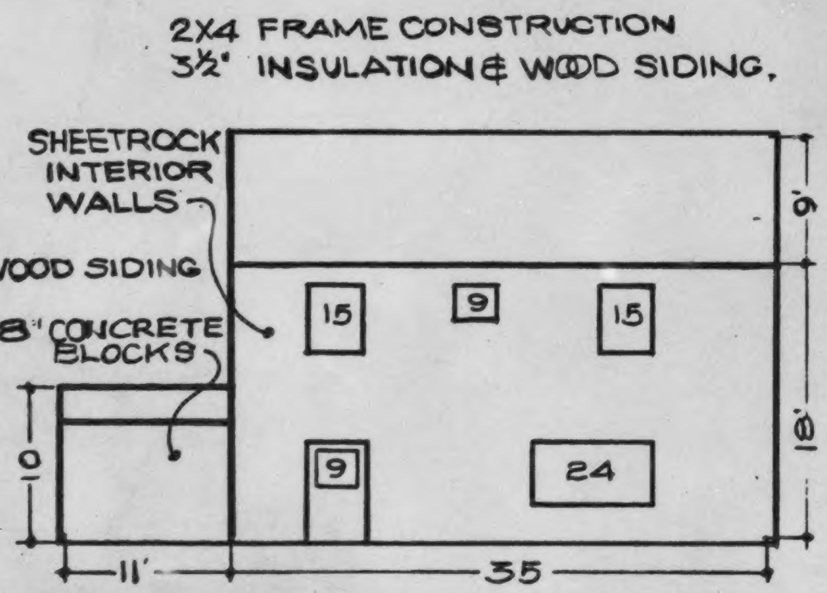
FLOOR PLAN(S)


N
W
E
S
FIRST FLOOR
L.R.
D.R.
FAM. R.
GARAGE
KIT.
1/2 B.
N
W
I
S
SECOND FLOOR
B.R.
B.R.
B.R.
B.R.
BATH

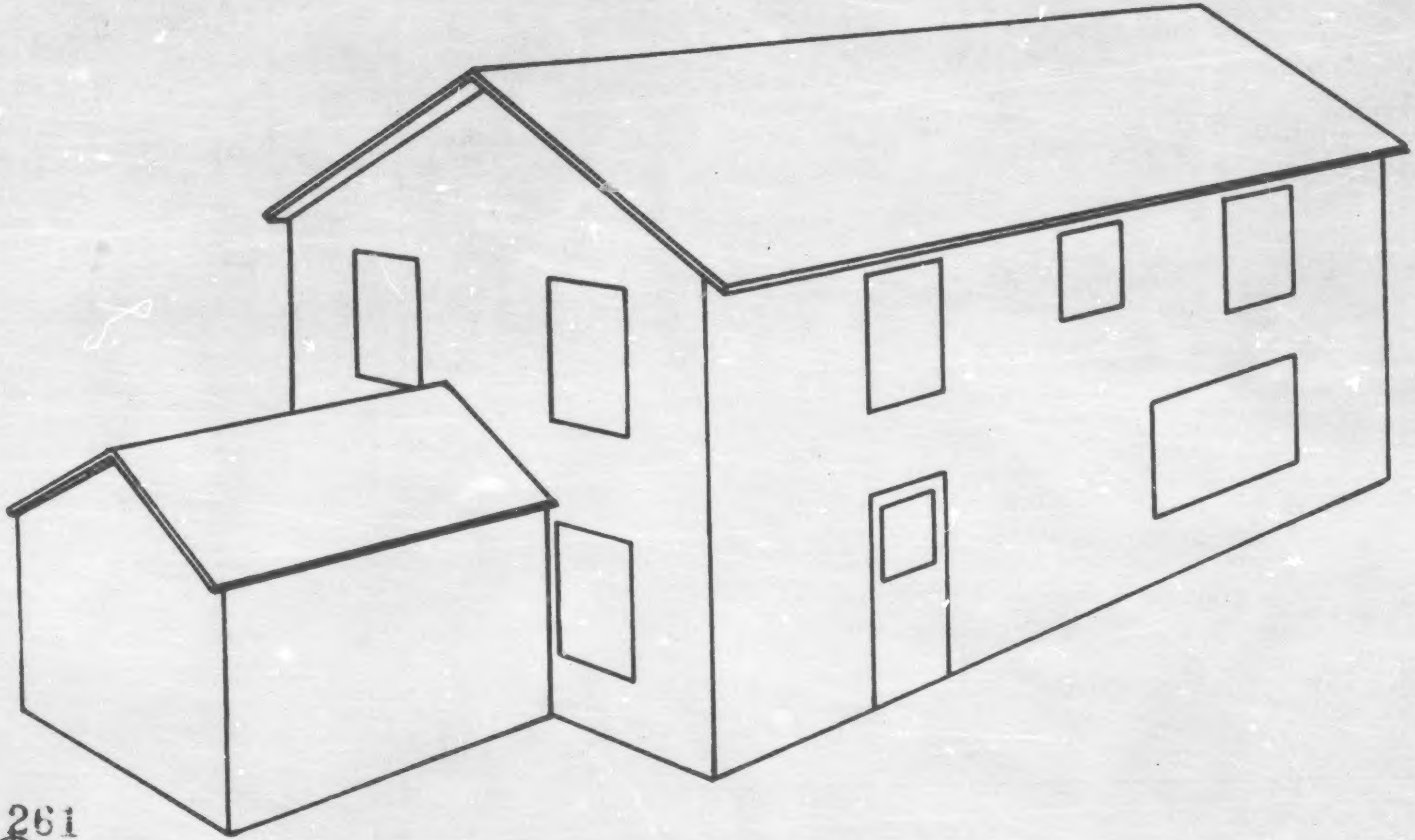
SOUTHWEST WALL


PITCH 3/8 OR APPROX. 37°
GAR.
24

SOUTHEAST WALL

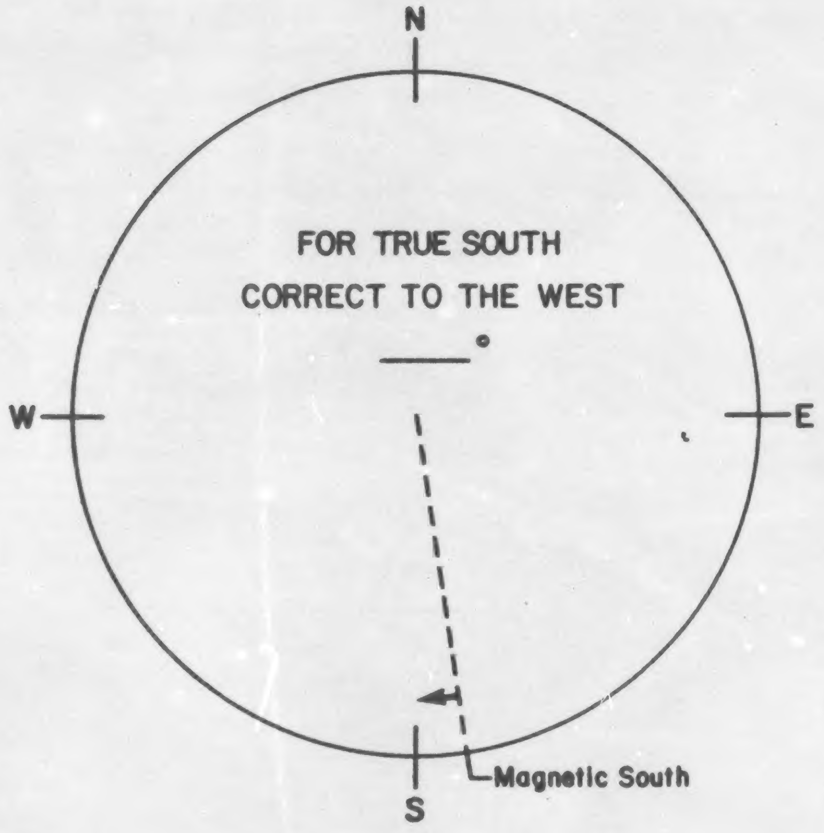

2X4 FRAME CONSTRUCTION
3½" INSULATION & WOOD SIDING.
SHEETROCK INTERIOR WALLS
WOOD SIDING
8" CONCRETE BLOCKS
15
9
15
9
24
9'
18'
10
11'
35

Sample Home Sketch

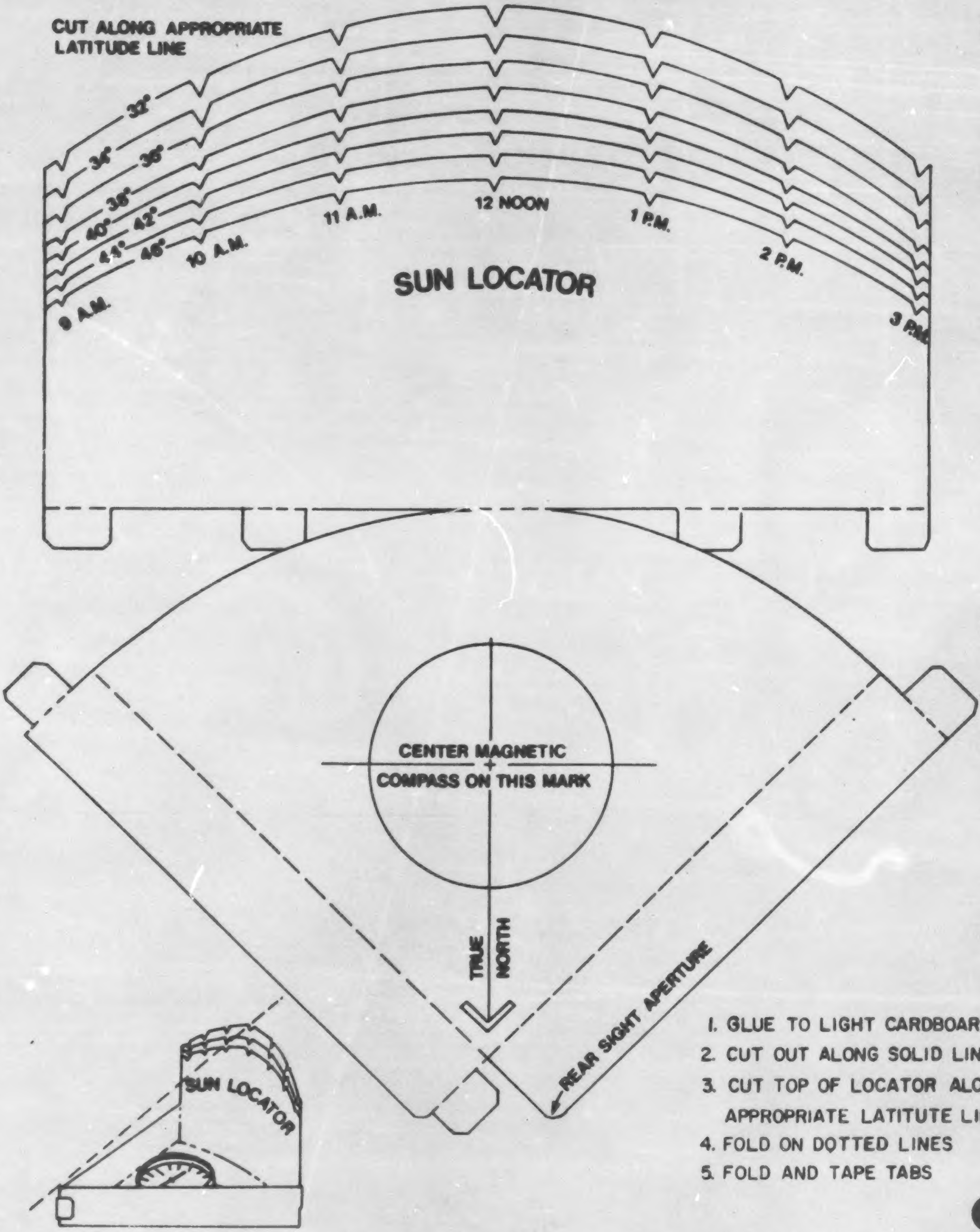


Source: Northeast Solar Energy Center
Solar Energy Education Department

True and Magnetic South


N
FOR TRUE SOUTH
CORRECT TO THE WEST
____°
W
E
Magnetic South
S

Source: Northeast Solar Energy Center


CUT ALONG APPROPRIATE LATITUDE LINE
32°
34°
36°
38°
40°
42°
44°
46°
9 A.M.
10 A.M.
11 A.M.
12 NOON
1 P.M.
2 P.M.
3 P.M.
SUN LOCATOR
CENTER MAGNETIC COMPASS ON THIS MARK
TRUE NORTH
REAR SIGHT APERTURE
SUN LOCATOR

1. GLUE TO LIGHT CARDBOARD
2. CUT OUT ALONG SOLID LINES
3. CUT TOP OF LOCATOR ALONG APPROPRIATE LATITUTE LINE
4. FOLD ON DOTTED LINES
5. FOLD AND TAPE TABS

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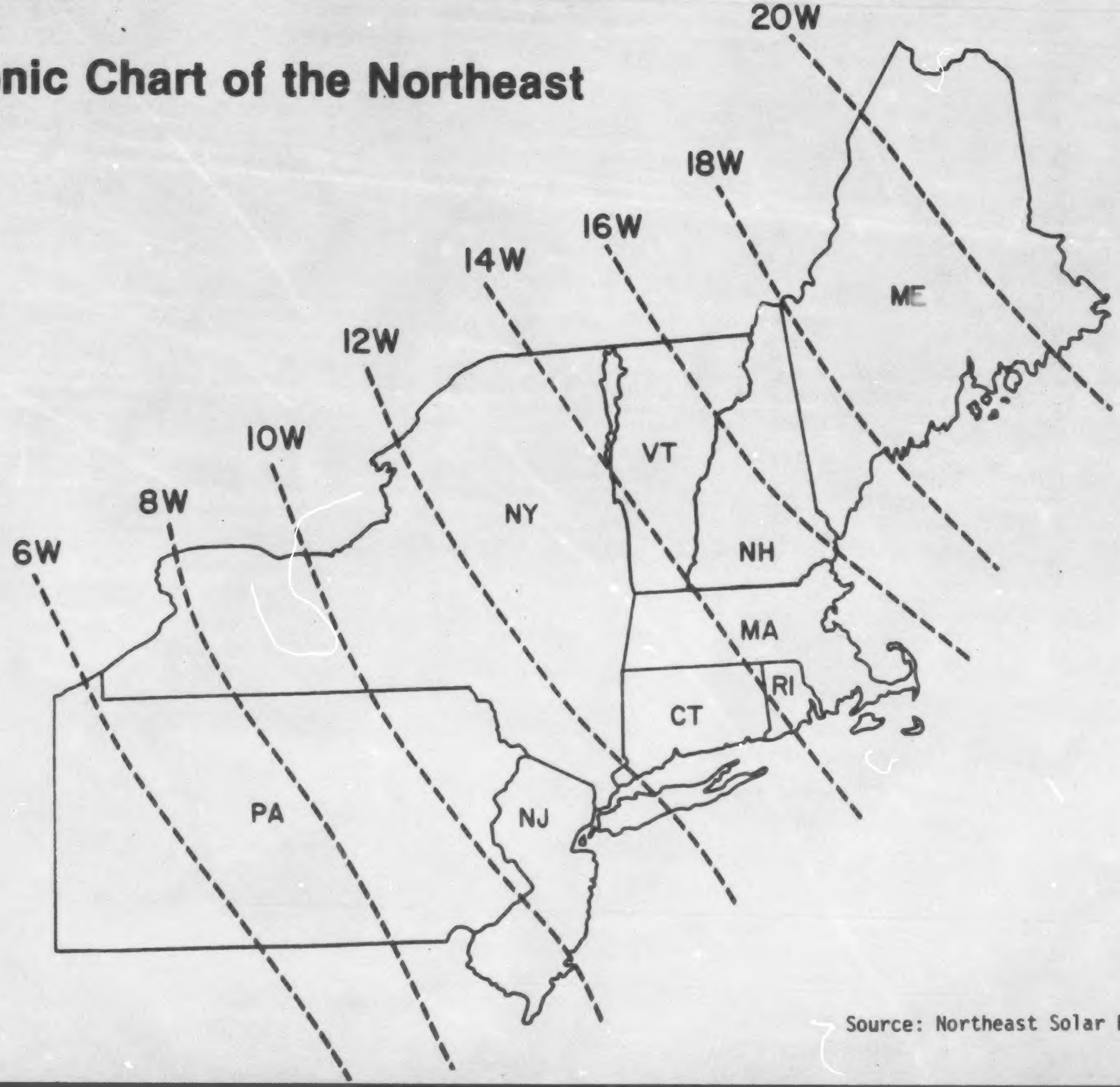
H-110

Isogonic Chart of the Northeast


20W
18W
16W
14W
12W
10W
8W
6W
ME
VT
NH
NY
MA
RI
CT
PA
NJ

Source: Northeast Solar Energy Center

E. Collector Mounting

1. Objectives

   a. To examine the various ways collectors are mounted

   b. To determine where the mountings should take place

2. Topics to be Discussed

   a. Location - determined by orientation restrictions

      1. Roof

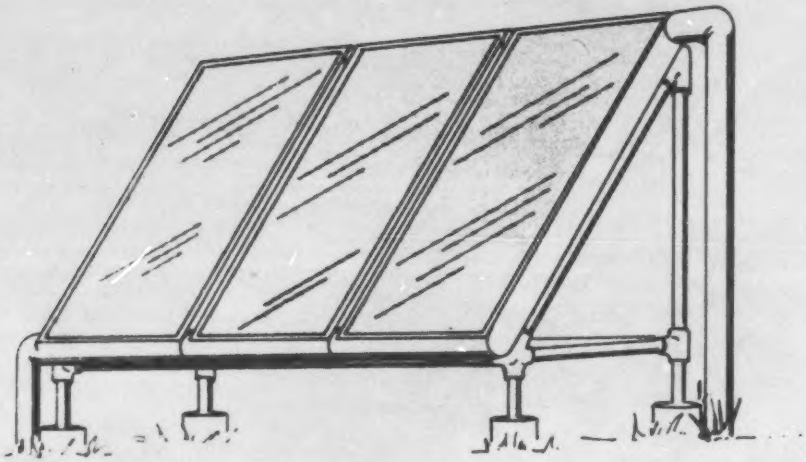
      2. Ground

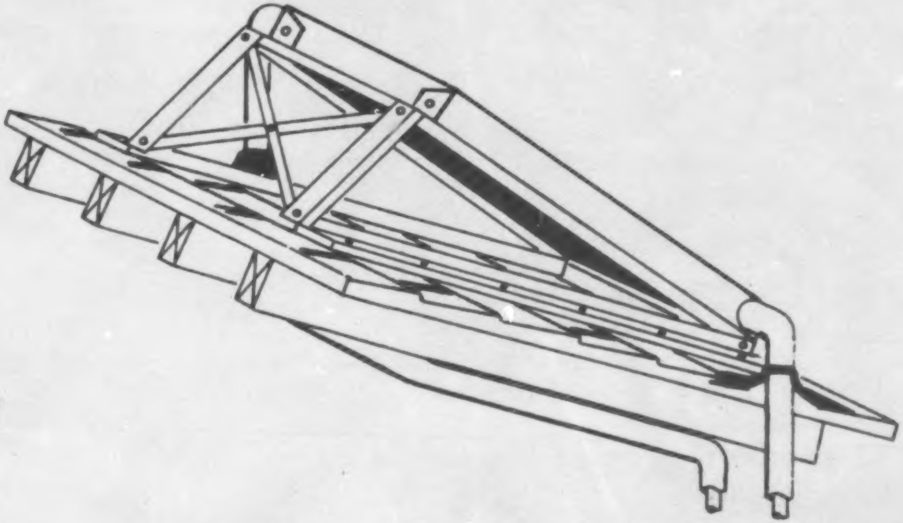
      3. Wall

   b. Manufactured mounting

      Advantages and disadvantages

Rack and Frame Mounting

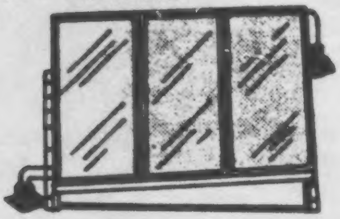




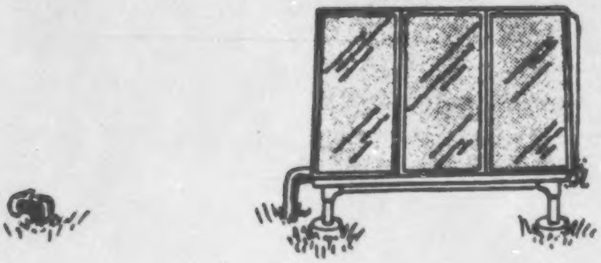
Source: Northeast Solar Energy Center

TYPICAL DOMESTIC HOT WATER COLLECTORS MOUNTING

DHW COLLECTOR ARRAY-
ROOF MOUNTED



DHW COLLECTOR
ARRAY- GROUND
MOUNTED



F. Collector Fluids

1. Objectives

   The student will be able to recognize the proper heat transfer fluids with regard to their compatability with various components within the system.

2. Topics for Discussion

   a. Propylene Glycol
   b. Silicone oils
   c. Ethylene Glycol
   d. Mineral oils
   e. Water
   f. Gases
      1. Compatibility with system components
         a. Galvanic action
         b. Corrosion
         c. Elastomer
      2. Toxicity
      3. Specific heat
      4. Freeze and boiling points
      5. Flash point

        6. Viscosity
        7. Temperature range evaluation

G. Controls

1. Objectives

   The student will be able to differentiate between available controllers and distinguish the advantages and disadvantages related to their operation.

2. Topics for Discussion

   a. Differential - how they cycle
   b. Proportional - how they cycle
   c. Sensors
      1. Types
      2. Location and mounting
   d. Wiring - high and low voltage
   e. Control panel mounting

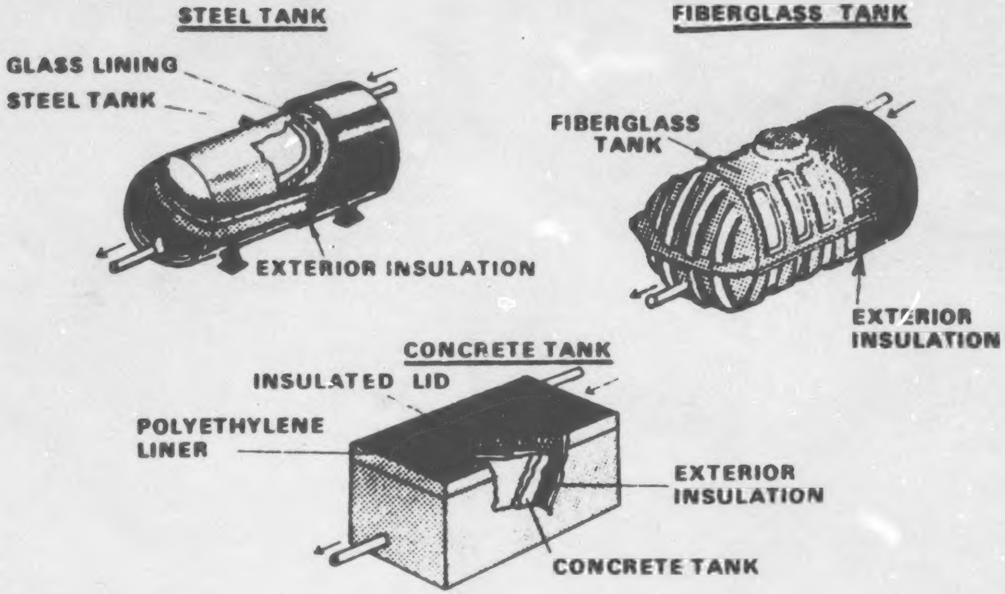
H. Storage

1. Objectives

   a. The student will be able to recognize and understand the basic principles of storing energy for future use

   b. The student will be able to understand the various methods of storage
   c. The student will be able to recognize the physical differences and characteristics of tanks
2. Topics for Discussion
   a. Methods of storage
   b. Tanks - use and construction
      1. Preheat
      2. Auxilliary
   c. Sizing
   d. Auxilliary heaters
   e. Conservation
      1. Reducing H_2O use
      2. Conserving captured energy

Water Storage for Liquid Systems


STEEL TANK
GLASS LINING
STEEL TANK
EXTERIOR INSULATION
FIBERGLASS TANK
FIBERGLASS TANK
EXTERIOR INSULATION
CONCRETE TANK
INSULATED LID
POLYETHYLENE LINER
EXTERIOR INSULATION
CONCRETE TANK

Source: Solar Energy for Buildings Handbook

I. Heat Exchangers

1. Objectives

The student will be able to apply the principles of heat exchanger selection properly with respect to installation limitations.

2. Topics for Discussion

a. Heat exchanger designs

b. Sizing

Efficiency

c. Installation and serviceability

J. System Plumbing Components

1. Objectives

The student will be able to identify and understand the operation of various plumbing components required in an active D.H.W. system.

2. Topics for Discussion

a. Circulation pumps

1. Pump sizing

2. Fluid compatibility

3. Types - fixed and variable

b. Check valve strainer(s)

c. Expansion tanks

  1. Types of diaphram material

  2. Pressure (pre-charged)

d. Air eliminator

  1. Automatic

  2. Manual

e. Gauges

  1. Temperature

  2. Pressure

  3. Flow meter (optional)

f. Pressure relief valve

g. Air separator (purger)

h. Ball oil gate valves (globe)

i. Temperature indicators

  1. Thermometer

  2. Sensors

j. Flow regulator/strainer

k. Schrader value

K. Piping Layouts for the Collector Loop

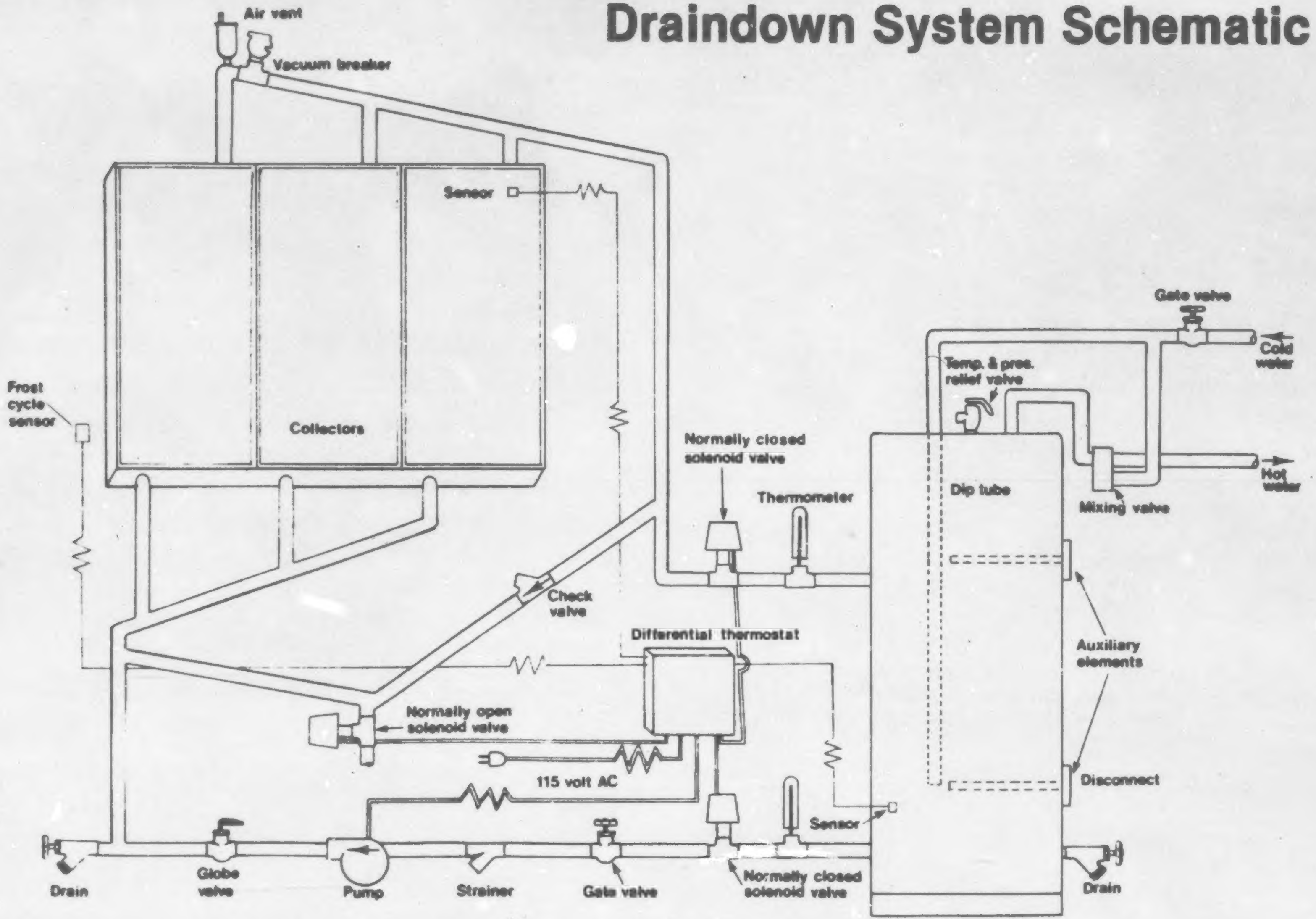
1. Objectives

The student will be able to understand the principles associated with the various collector configurations

2. Topics for Discussion

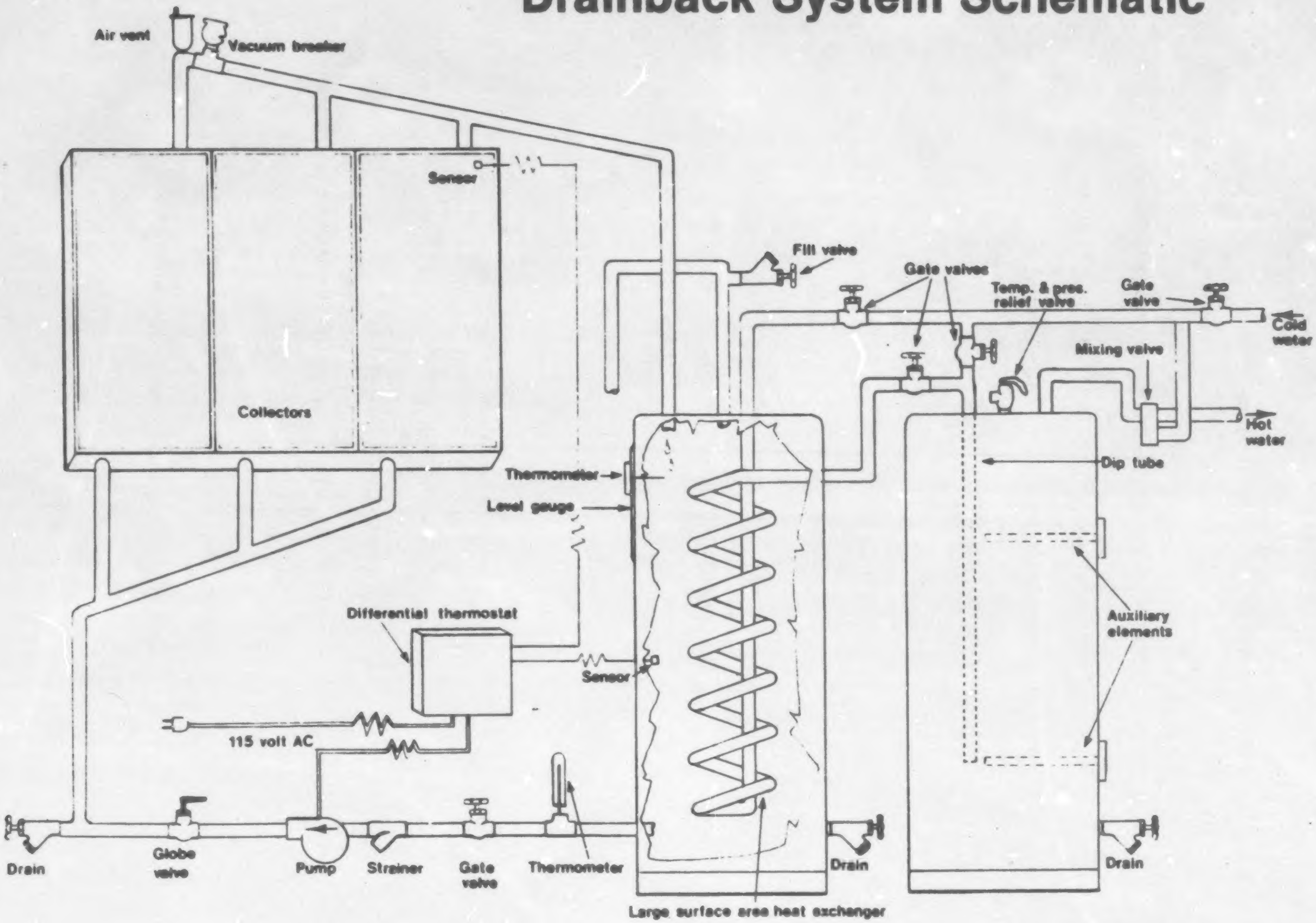
    a. Closed loop
    b. Drain down
    c. Draw back
    d. Thermosiphon
    e. Insulation and support

Draindown System Schematic


Air vent
Vacuum breaker
Sensor
Collectors
Frost cycle sensor
Check valve
Differential thermostat
Normally open solenoid valve
115 volt AC
Normally closed solenoid valve
Thermometer
Gate valve
Cold water
Temp. & pres. relief valve
Hot water
Dip tube
Mixing valve
Auxiliary elements
Disconnect
Sensor
Drain
Globe valve
Pump
Strainer
Gate valve
Normally closed solenoid valve
Drain

Source: Installation Guidelines for Solar DHW Systems

Drainback System Schematic


Air vent
Vacuum breaker
Sensor
Collectors
Fill valve
Gate valves
Temp. & pres. relief valve
Gate valve
Cold water
Mixing valve
Hot water
Dip tube
Thermometer
Level gauge
Differential thermostat
Sensor
Auxiliary elements
115 volt AC
Drain
Globe valve
Pump
Strainer
Gate valve
Thermometer
Drain
Drain
Large surface area heat exchanger

Source: Installation Guidelines for Solar DHW Systems

L. Plumbing of the D.H.W. Supply System

1. Objectives

   The student will be able to adapt the solar hot water system to operate in conduction with the existing hot water system.

2. Topics for Discussion

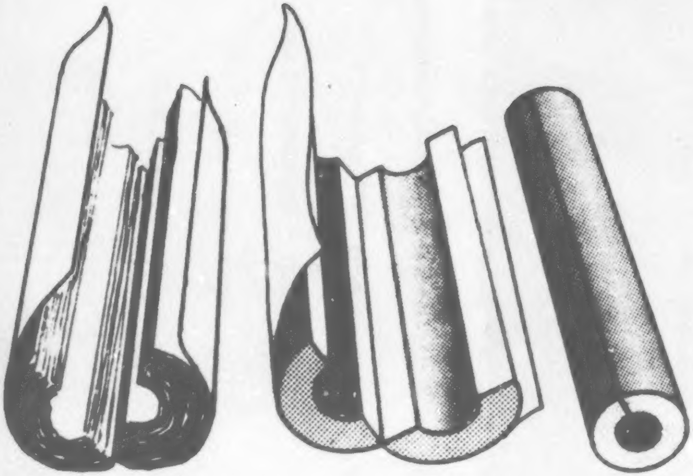
   a. Hook up to solar tank
      1. Code
      2. License
   b. Auxiliary tank - if used
   c. Tankless hot water coil (preheat)
   d. Auxiliary heating elements
      1. Hot water booster
      2. Hot water restrictors
      3. Dump excess hot water
      4. Control of high limit
      5. Prevent stagnation

M. Piping, Plumbing Fittings and Domestic Hot Water Components

1. Objectives

   The student will be able to identify and select the proper piping, plumbing fittings

Pipe Insulation



FIBERGLASS URETHANE, AND FOAM RUBBER INSULATION

INSULATING VALUE PER INCH OF THICKNESS

Fiberglass	R-3
Elastomers	R-3.5
Urethane	R-6.5
Isocyanurates	R-7+

Source: Solar Energy for Buildings Handbook and components for various domestic hot water applications.

2. Topics for Discussion

Check list -

a. Plumbing symbology

b. ANSI drawing standards

c. Proper schematic drawing for D.H.W. planning

d. Plumbing fittings

    1. Piping/tubing
    2. Els - elbows and multi L's
    3. Adapters - internal/external
    4. Baseboard "T"'s/vents
    5. Soldering - equipment and tools
    6. Temperature gauge
    7. Hosing clamps (S.S.)
    8. Strainer serviceability
    9. Valves
    10. Couplings
    11. Temp. press. relief valve
    12. Valve adjustment
    13. Unions
    14. Flanges

3. Specific plumbing supplies - (provided by installer)

   a. Solar - (all copper

      1. 3/4 L pipe
      2. 3/4 ells 90°
      3. 1" to 3/4 adapter
      4. 1" couplings (slip)
      5. 3/4 male to 3/4 female adapter (Thread type)
      6. 3/4 baseboard tee (vent)
      7. 3/4 sweat x 3/4 sweat x ½ NPT male tee (temp gauge)
      8. Coin vent
      9. 3/4" couplings
      10. 1¼ stainless steel hose clamps - strainer serviceable

   b. Domestic hot water

      1. ½ "L" pipe
      2. ½" ells 90°
      3. ½" couplings
      4. ½" (sweat) valves
      5. 3/4 threaded male to ½ sweat female
      6. ½ tees

7. ½ ells 45°

8. Back – flo preventer temperature/pressure relief valve – tempering valve

N. Electrical System

1. Objectives

The student will be able to identify the electrical requirements related to the operation of a solar D.H.W. system.

2. Topics for Discussion

a. Sensor wiring

1. Collector

2. Storage

b. Control wiring

1. Sensors

2. Pump

3. Control feed

c. Pump wiring

1. Factory wired

2. Field wired

d. Auxiliary heating element

1. Timer switch

2. Thermostat (factory)

- e. Code and license requirement
  - 1. Homeowner
  - 2. Installer (non-owner)
- f. Electrical equipment and supplies (see list)

3. Electrical supplies
   - a. 18/2 for sensor wiring
   - b. 14-2/G wire for controller (supply)
   - c. 12-2/ auxilliary elements
   - d. Handy box
   - e. Duplex out (3 prong)
   - f. Cover plates
   - g. Staples for wire (required sizes)
   - h. Crimp connectors for box or panel (if necessary)
   - i. Wire nuts for controller thermistors
   - j. Plywood
   - k. Masonry fasteners
   - l. Box/romex connectors
   - m. 14/2 bx cable (greenfield)
   - n. Wire strippers/cutter
   - o. Romex cable ripper
   - p. Assorted sheet metal screws
   - q. Circuit breakers
   - r. Service switches

O. Specifically Applied Tools and Equipment Checklist for D.H.W. Use

Acetylene torch - Mapp tank
Flint striker
Non-corroding flux
95/5 solder
Plumbers cloth
Tube cutter for 3/4" copper
2 - 14" pipe wrenches
1 - 3/8" drive socket wrench set
1 - 8" crescent wrench
Channel - lock pliers
Vise grip pliers
Wire strippers/crimpers
Hammer
Cross-cut hand saw
Hack saw
Caulking gun
100' grounded extension cord
Carpenter's level
Carpenter's square

Compass
50' tape measure
Sharp knife with 6" blade or more
Scissors
Dishwashing liquid
Electrician's tape
Assorted screwdrivers
Fill pump
3 - washing machine hoses with female fittings both ends
Intake strainer for fill line
½" variable speed drill
1" high speed bit - pipe
½" high speed bit thd. rod
5 gallon plastic bucket
Bicycle pump or compressor
Flashlight
Safety goggles or equivalent
Rags
Work goves

Ladders

Rubber soled shoes

100' x ½" rope

Toothbrush

Inclinometer

50/50 solder

Ruler - 6' zig-zag or 10' - 12' tape

Wire brush - pipe cleaner

Pencil

Teflon tape - water

RVT - 730 and primer 1200 - silicone

Socket set

Allen wrenches

Wire crimpers

IX. ENVELOPE AND HYBRID CLIMATE CONTROL SYSTEM

I. Introduction

A. Envelope or double shell climate control systems are those heating and cooling systems; i.e., consisting of a structure inside another structure. Within the primary shell is an area to be heated or cooled, around this primary shell is a secondary shell that is directly exposed to current weather conditions. The primary shell is enclosed within a controlled climate and protected from weather extremes.

Components of this system include heat transfer mechanisms, transport systems and a thermal storage/release unit. The airspace between the two shells forms a convective loop with the north and south walls, an air plenum in the roof and a storage/release area under the primary shell. The convective loop utilizes the vertical movement of an air current, where the temperature and atmospheric pressure of two air spaces are unequal.

Heated air rises within the south collective wall, passes through the overhead or attic airspace, down the north wall to storage in an underground crawl space or basement. During the night, this process reverses, to release heated air from storage, thus providing minimal temperature fluctuation. Specific technical information regarding this envelope system may be absent or recently modified due to contemporary applications first acknowledged in the U.S.A. during 1979.

B. Hybrid climate control systems are those heating and cooling systems; i.e., operated by moving heated or cooled air by electrical or mechanical devices. Employed within any existing passive solar air system, it modifies air movement, especially where a large volume of air must be transported over a great distance. Hybrid systems are mentioned within the envelope C.C.S., as heated air must travel around the perimeter of the primary shell.

II. Implementation

There are six variable components for envelope/hybrid system implementation.

A. The thermal absorption area in the southern wall and/ or roof, is an air space which varies in size, materials and method of operation. This area may be a greenhouse, sunspace or of a flat collective type as part of the convective loop. More specific design information may be found in the passive air collector unit.

B. The upper air transport plenum may have a horizontal, curved or diagonal direction of flow. Heat loss must be controlled by insulation, or modification of that air passage. This duct work can be hollow or separated into thin films of air on route to storage or release.

C. The northern air plenum also must be protected from heat loss as per the upper air passage. Minimal use of glazing on this side will add to heat conductivity and subsequent loss.

D. The thermal storage/release area may change in size, method, and materials. A ceramic material may be lava rocks, gravel, concrete blocks, earth or other hollow concrete forms. Effectiveness is still being tested. The method of ducting heated air around or through this area is also a debated item. More specific design information may be found in the thermal mass storage unit.

E. In the summer cooling stage, the envelope system becomes a one direction air passage. Cooling tubes running underground from the storage area to the outside environment pull cooler air into and around the double shell. Warmer air is exhausted at the peak of the structure by means of vents or a thermal chimney.

F. Hybrid adaptions assist air movement in heating and cooling stages where air flow or change is highly desired. Electrically driven mechanical apparatus may be manually or thermally controlled to exchange warm or cool air.

III. Behavioral Objectives

Due to the absence of specific technical design information, these objectives are experimental in nature. No proven measurement of system efficiency places the research and design objectives into a trial creation.

Whether project or building oriented, the following objectives should be expanded to meet the specific level of students' needs. Upon completion of this unit, the student will:

1. Determine and state the needs of that project or building.

2. Complete original research with all pertinent information related to the project or building.

3. Analyze data compiled through the original research.

4. Arrive at an objective conclusion with regard to the envelope/hygrid system.

5. Design and draft all drawings and details of the envelope/hybrid structure.

6. Obtain materials for construction of the project or building.

7. Construct or assemble the project or building, including a minimum of four variables in an envelope/hybrid system.

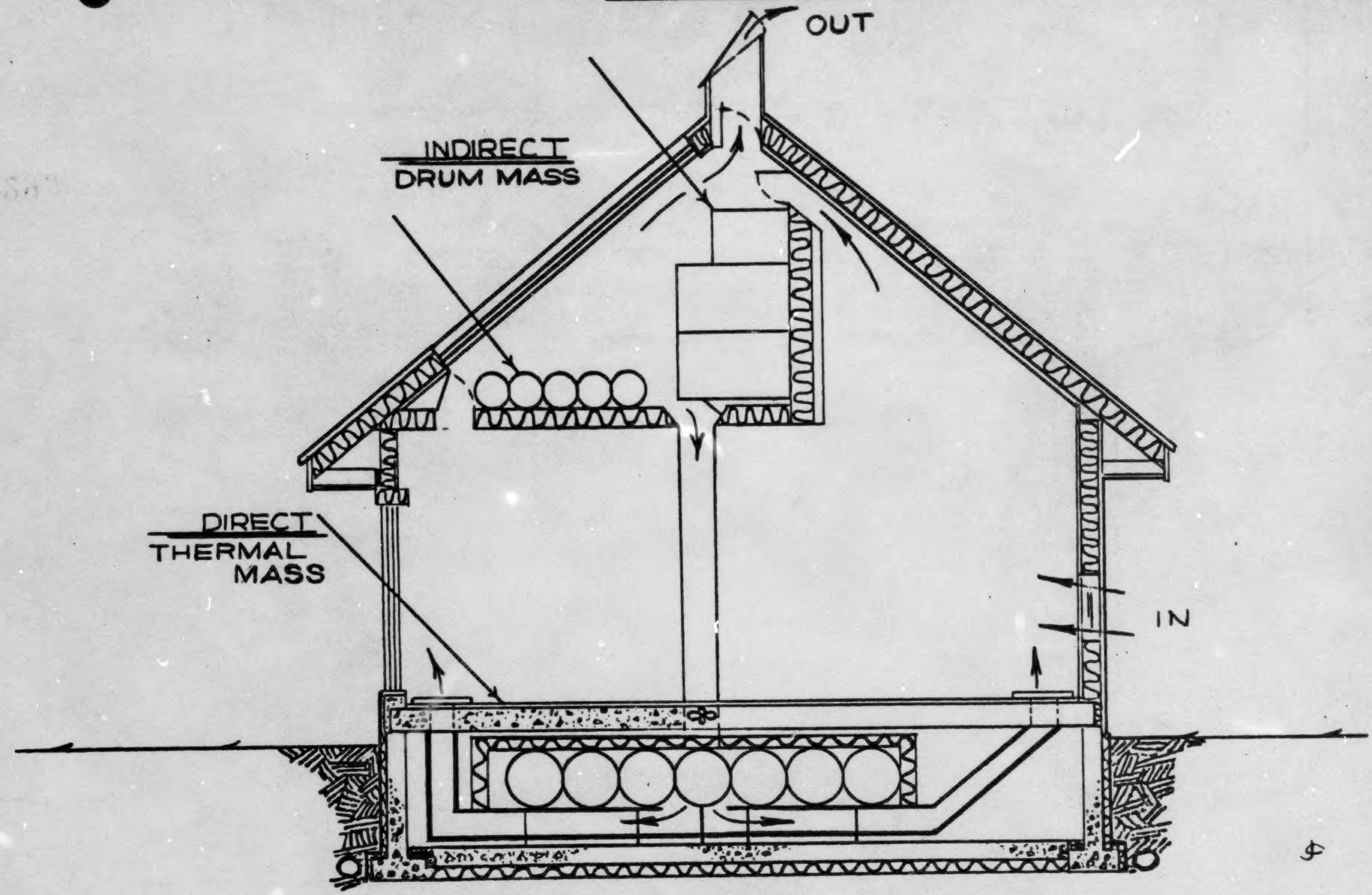
8. Design an experimental measurement of the system's efficiency.

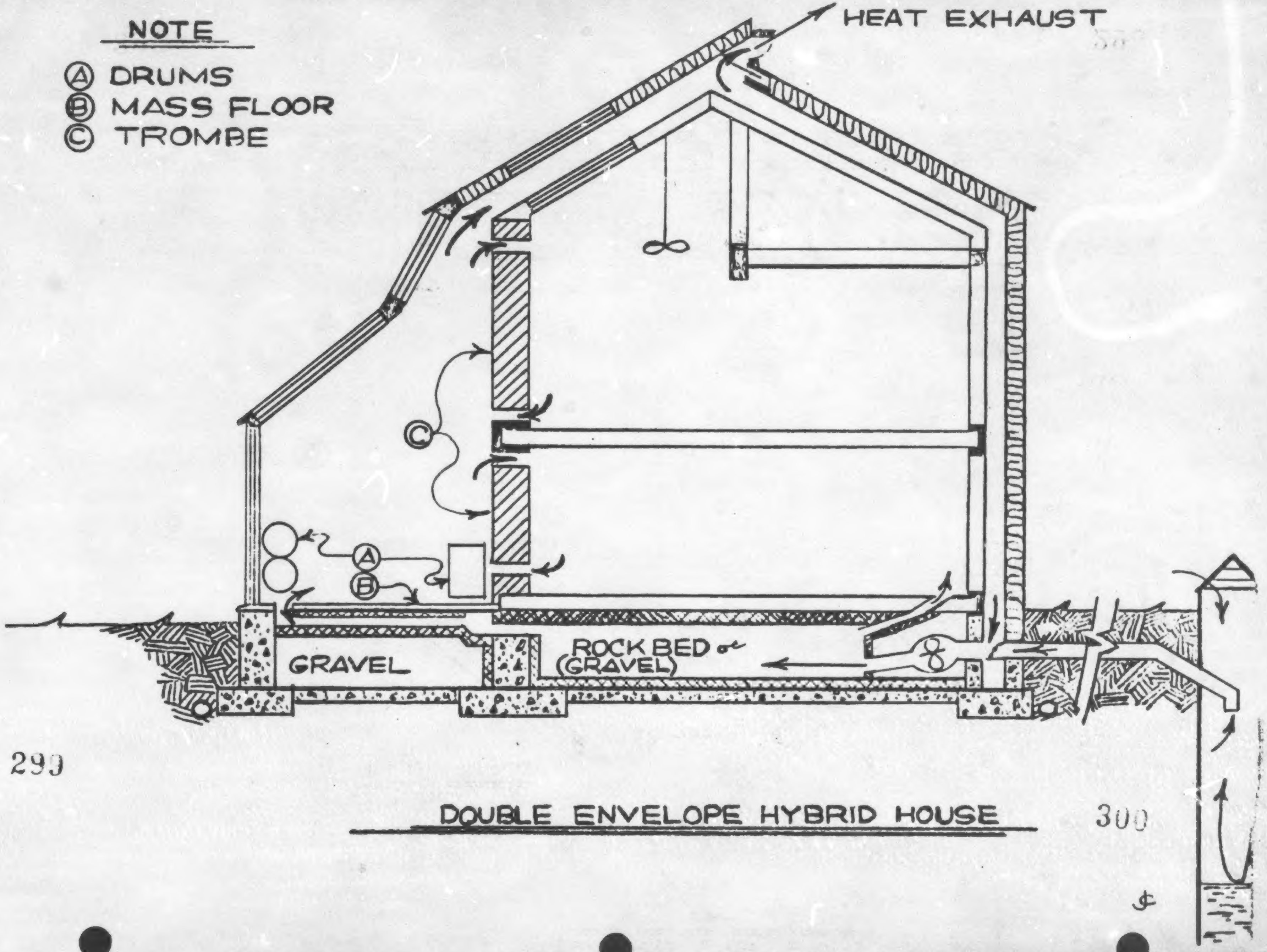
9. Fine - tune the system with hybrid applications.

10. Apply envelope/hybrid methods to any existing residential and livestock structures as well as to other needs, i.e.,

    a. Public sports arenas
    b. Schools
    c. Churches
    d. Garages
    e. Recreational
    f. Buses
    g. Autos
    h. Ships
    i. Planes
    j. Trucks
    k. Trains
    l. Etc.

HYBRID SYSTEM


OUT
INDIRECT
DRUM MASS
DIRECT
THERMAL
MASS
IN


NOTE
Ⓐ DRUMS
Ⓑ MASS FLOOR
Ⓒ TROMBE
HEAT EXHAUST
Ⓒ
Ⓐ
Ⓑ
GRAVEL
ROCK BED or (GRAVEL)

299

DOUBLE ENVELOPE HYBRID HOUSE

300

JC